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SOIL EROSION BY RAINSTORMS

W. D. ELLISON

EDWARD LEE THORNDIKE: 1874-1949

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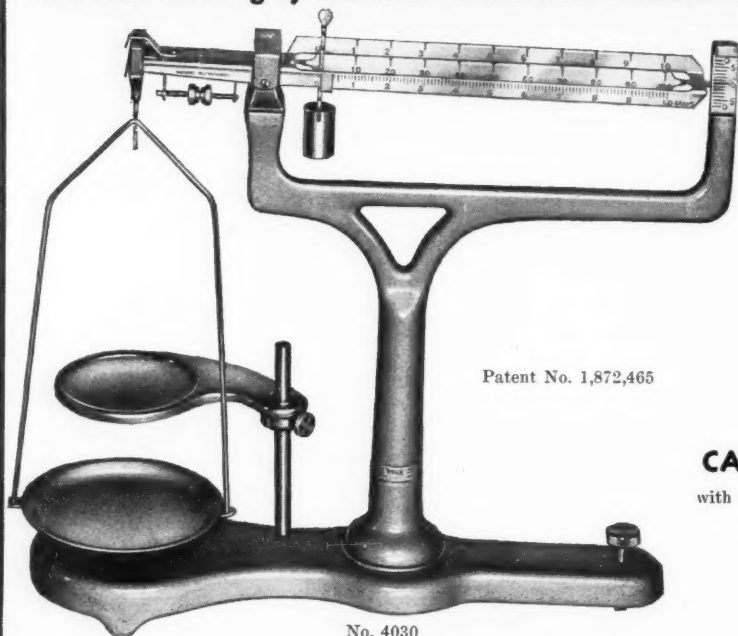
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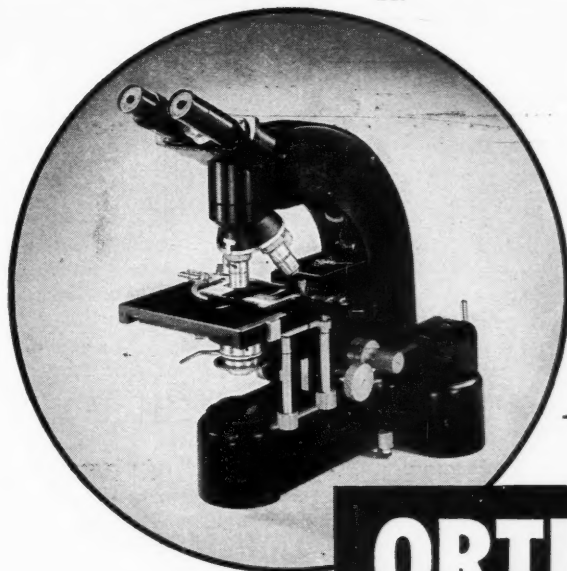
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WHEN A VIOLENT RAINSTORM strikes a bare field there are two erosive agents at work—the falling raindrops and the flowing surface water. Each works through a different erosion process, and each forms different products.

The basic erosion process is one of detaching and transporting soil materials. Falling raindrops accomplish this through splashing particles of soil into the air (splash erosion). The runoff erodes by a scouring action as it flows downslope (scour erosion). In the splash erosion process the energy of the raindrops is applied uniformly across whole fields, whereas in scour erosion the energy of the runoff concentrates along narrow lines of flow.

The effects of these two erosion processes are very different. The raindrops erode thin layers of soil over broad reaches of hillsides, whereas erosion by surface flow tends to carve rills and gullies along the lines where runoff concentrates.

On smooth and level field surfaces, the splash process merely "kicks" particles of soil back and forth, without causing a net loss from any point. But on a hillside, the splashed soil creeps downslope. Measurements have shown that a violent rainstorm may have a splash capacity of more than 100 tons per acre. Still other measurements have shown that on a 10 percent slope this downgrade transportation of splashed soil is about three times the upgrade. The downslope movement may be observed whenever a rainstorm beats down and flattens a small pile of sand in an open yard. There is seldom any surface flow down the sides of the pile, and all of the sand must be transported by the splashes of the falling raindrops. (See Fig. 1.)

Splash erosion moves soil down field slopes in about the same way that it moves sand down from the top of a pile. However, under most field conditions, its action is accelerated by runoff. Each time splashed particles fall back into the runoff they may be floated, dragged, or rolled some distance downslope before being deposited or coming to rest on the surface. If velocities are low, and if most of the soil particles are large and heavy, the runoff may float out only the

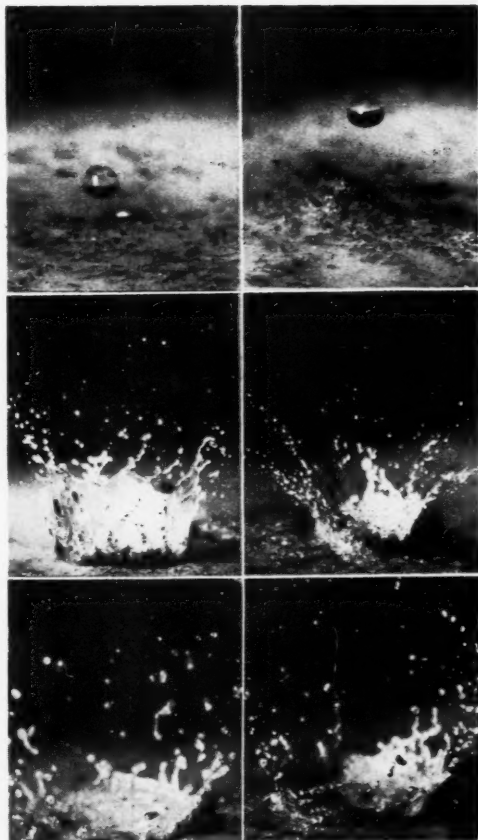


FIG. 1. Splash erosion. *Left*: top—a falling raindrop approaches a soil having a thin film of water covering; middle—the splash reaction throws soil and water into the air; bottom—the cavity lends proof of the effects of splash erosion on the soil. *Right*: top—a falling raindrop approaches a wet soil; middle—there is not enough water to raise a continuous film as in the photograph at the left; bottom—the cavity indicates that the soil has been moved downslope and what remains is puddled and damaged in other ways. Photographs show actual size. They were made by Naval Research Laboratory, Washington, D. C. V. P. Robey, photographer.

organic matter, clay fractions, and other fine and light materials.

The scour erosion process acts very differently. It is limited in the main to narrow flow lines and, contrary to general belief, it does not usually cause sheet erosion, except as it is assisted by what we shall term a feeder agent. This feeder agent detaches particles from smooth field surfaces outside the rills and gullies and moves them into the lines of concentrated flow. On cropped fields the splashing raindrops and many of the ordinary tillage implements serve as feeders, moving surface soil into the flow lines and thus producing sheet erosion. But on lands that are permanently in good grass covers, these feeder agents are not active. Here erosion is limited to gullies, and sheet erosion effects do not appear.

So long as man has tilled the soil he has had a constant struggle to maintain his lands against damages by soil erosion. Unfortunately, this struggle has been made more difficult through his failure to recognize the splash erosion process. Until very recently, this process represented an important missing link in soil erosion science. Efforts to check soil erosion were based almost entirely on controlling surface flow with terraces, contour ridge rows, and other types of contour impediments which retard velocities of runoff and thereby curtail the erosive capacities of flowing surface water. Such practices tend to prevent gully-ing, and to reduce the downhill transportation of splashed soil particles that fall back into the runoff. But they are not effective in preventing the downslope creep of soil in splash erosion processes.

A study of both ancient and modern soil conservation undertakings discloses failures which probably should be charged to uncontrolled splash erosion. Some of these failures occurred even though surface flow seems to have been effectively reduced. One example was reported by Lowdermilk (7). Following an inspection of lands about the city of Jerash (formerly called Gerasa), located on the Chrysorrhoas, which leads into the Zerka, in the valley of the Jordan, he reported in 1939 that he found soils washed off to bedrock, in spite of rock-walled terraces.

A development similar to that reported by Lowdermilk, but on lands protected with modern terraces, was reported by Cox (2), from Guthrie, Oklahoma. Following a checkup on an experimental field that had been terraced, he stated that over the last eight years it had lost from 6 to 8 inches of soil. (See Fig. 2.)

To control splash erosion we must break the fall velocities of raindrops before they strike the ground. This may be done with mulches of straw or leaves, or with dense growths of vegetal covers on the ground. Even before the splash erosion process was recognized and explored experimentally, vegetal covers were



FIG. 2. Terraced field at Guthrie, Oklahoma. Soil Conservation Service photo.

known to have some beneficial effects in conserving soil and water. Plato must have had some of these benefits in mind when, according to Toynbee (9), he wrote of Attica:

Contemporary Attica may accurately be described as a mere relic of the original country, as I shall proceed to explain. . . . All of the rich, soft soil has moulded away, leaving a country of skin and bones. . . . There were also many lofty cultivated trees, while the country produced boundless pastures for cattle. The annual supply of rainfall was not lost, as it is at present, through being allowed to flow over the denuded surface into the sea, but was received by the country, in all its abundance, into her bosom, where she stored it in her impervious potter's earth and so was able to discharge the drainage of the heights into the hollows in the form of springs and rivers with an abundant volume and a wide territorial distribution.

In 1877, Wollny (10), a German scientist, wrote about the effects of a heating rain in breaking down the soil structure, and the protective effects of a vegetal cover in reducing these damages.

Some of the present-day experiments that stand out as classics in this field were conducted by Laws (6), and Borst and Woodburn (1). In both studies the effects of variations in raindrop impacts on the amounts of soils carried in the runoff waters were measured. Results showed conclusively that increases in drop impacts tended to increase the amounts of soils carried by the runoff. However, these experimenters apparently did not recognize splash erosion as an important independent erosion process.

The first known reports on splash erosion were made by the writer (3, 4, 5). Techniques entirely new to the field of soil erosion were developed for studying the splashed soil. Sreenivas (8) later used these techniques to measure the protection afforded soils by different kinds and amounts of vegetal covers. Woodburn (11) also employed them to determine the detachability of different soils when exposed to rain-

drop action. Work along these lines has progressed so as to permit fairly exact determination of the amount of vegetal cover required to preserve each different soil, and the protective values of different kinds and amounts of mulches and growing vegetations can also be measured. These developments now enable us to match each different soil with a cover tailor-made to its protective requirements.

RESULTS OF SOIL EROSION

Splash and scour erosion processes damage the land in at least four important ways. They carve gullies, they remove sheets of surface soil, they remove organic matter and other soil nutrients even without significant net loss of soil from the surface of the land, and they puddle soils, making them droughty and reducing productivity.

"Gully erosion" and "sheet erosion" are commonly accepted terms. But we need another term, "puddle erosion," to distinguish between puddling caused by erosion and that caused by other agents. Also, we need the term "fertility erosion," to denote the removal of a soil's fertility elements by an erosive agent. These terms will clarify some of our problems in erosion control. Many smooth and level lands do not need protection against gully or sheet erosion but do require control measures to check puddle or fertility erosion—that is, the soil needs a cover to protect it from raindrop impact.

Puddle erosion. Raindrops, working through the splash process, cause most of the damage in puddle erosion. They break down clods and crumbs of soil and compact these broken materials. The inflow of surface water made muddy by splash further seals surface cracks and pores and tends to "waterproof" the land.

The first step in the control of damage by soil puddling is to control splash erosion. Some recent tests on open ranges disclosed that overgrazing, which removed too much of the grass, permitted excessive splash erosion to make the land almost waterproof. These tests showed that with a good grass cover, containing about 3 tons of forage and litter per acre, only about half a ton of soil per acre was splashed, and the water intake was 2.36 inches during a 15-minute period.

On other areas, where there was less forage and litter cover, the splash erosion tended to increase, and the water intake to decrease, with each reduction in the vegetal materials. Finally, on bare areas where there was no cover at all, 70 tons of soil was splashed on each acre, and water intake was reduced to 0.10 inch in 15 minutes.

These reductions in water intake can be charged in the main to surface sealing. But splashing raindrops

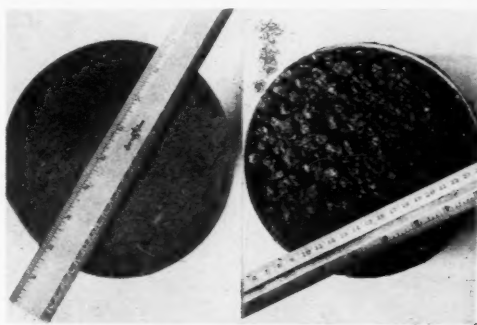


FIG. 3. Puddle erosion hardens the land so that water does not enter freely. Soil at the left has been subject to puddle erosion; that at the right has not. Soil Conservation Service photo.

may puddle and seal deep sections of the profile, as well as the surface, on many soil types. Turbid water, charged with colloidal materials, sometimes enters the soil through large surface openings. Upon reaching the bottoms of such openings these materials are deposited to form a dense and highly impermeable core. It is my belief that these actions have a hardening effect which makes many soils less pervious, decreases intake of rainfall, curtails yields to ground water, and increases runoff. This imperviousness develops at different rates on different soils. Exploratory examinations of several field situations has indicated that it may take from 25 to 1000 years of farming (with uncontrolled splash erosion) for this deep sealing to develop an important effect on some of the different soils. (See Fig. 3.)

There are indications that erosion control practices made top-heavy with contouring operations, where splash erosion continues uncontrolled, may aggravate this deep sealing and hasten the land-hardening process on many soil types. On these soils, practices that are employed for water conservation and flood control will in the long run defeat the very purposes for which they are intended.

Fertility erosion. The effects of fertility erosion may be seen on level fields of bare sandy soils, after a heavy rain. (See Fig. 4.) They are about the same as would be produced by washing a thin layer of surface soil in a washing machine—there is little more than coarse sand left.

Out on open fields the churning action of splashing raindrops breaks down clods and crumbs of soil and releases chemicals, organic matter, and clay fractions into the surface water. The runoff, made turbulent by the splashes, may carry considerable amounts of these important parts of the soil off the fields.

The fertility erosion process, which removes only the lighter elements from the heavy sands, can be more

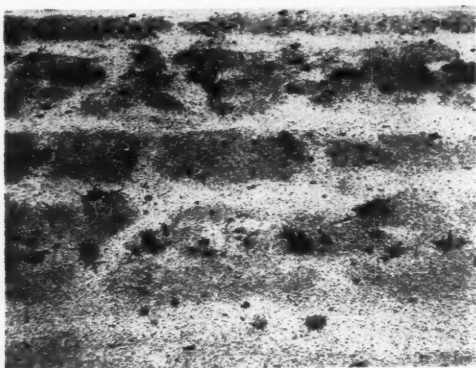


FIG. 4. Fertility erosion is an important process in making deserts. It removes the soil's fertility elements and destroys the land's water-holding capacity. Soil Conservation Service photo.

injurious to sandy lands than sheet erosion, which removes the whole soil. Some fields have been damaged to an extent that the plow layer is composed almost wholly of coarse sand. This material has lost not only fertility, but also a considerable part of its water-holding capacity. During hot summer weather it may become droughty within a few days after a heavy rainstorm.

Many efforts have been made to build up the organic matter of these soils. Using organic matter in this way while fertility erosion remains uncontrolled is a wasteful practice. Proper erosion control would prevent the loss in the first place.

Sheet erosion. The effects of sheet erosion are widely recognized. (See Fig. 5.) They usually appear first near the tops of slopes, where subsoil may be exposed across broad reaches. From here they are extended downslope by rainstorms.



FIG. 5. Sheet erosion. Falling raindrops splash the soil down from tops of slopes, tending to flatten them, just as they flatten sandpiles in open yards. Soil Conservation Service photo.

The difference between the processes that cause sheet erosion and those that cause fertility erosion depends largely on soil transportation. Where the transportation is insufficient to remove all of the soil particles that are detached and set in motion by the splash, only the lighter materials may be lost from the eroded area and the result will be fertility erosion. But where the erosive agents have sufficient transporting capacity to keep the whole soil in motion downslope, the result will be sheet erosion. Several important factors control the transportation phase of erosion processes. These include the slope of the land, the transportability of the soil, the transporting capacity of the erosive agents and the surface conditions over which the water flows.

The effects of sheet erosion are most injurious to lands having a thin layer of surface soil underlain



FIG. 6. Gully erosion is a product of the scour process. On this small plot the rainmaker was lowered to the surface and drops were released without impact. The soil was only about one inch deep, so that some of the washes spread in width more than they would have in deeper soil. If the raindrops had been applied with impact they would have served as a feeder agent and all of the soil would have been washed away. Soil Conservation Service photo.

with hard rock. On these the loss of only a shallow depth of soil will completely destroy productivity. Sheet erosion is least injurious to lands where there is little difference in the productive capacities of the surface soils and their subsoils, particularly if the subsoils are deep and of a quality that is easily made productive.

Gully erosion. Flowing surface water is the controlling erosive agent in carving gullies. (See Fig. 6.) However, splashing raindrops may contribute to the process, in at least two ways: through puddling the land surface and thereby increasing the amounts of runoff available to do the gully carving, and through splashing abrasive soil materials into suspension.

Flowing surface water working through the scour

process was the principal erosive agent active in carving the Grand Canyon, the river systems, and myriads of small valleys. The erosion that carved the important drainage systems must be classed as beneficial to the land. But aside from creating channels needed for drainage purposes, gullying is usually a very destructive process. A gully often dissects sloping lands to the extent of making them unworkable or even impassable.

Gully-filling projects have been widely publicized during the past two years and this work has been hailed as giving new birth to farm lands. Its value should not be underestimated, but such operations only repair damages to the terrain, they do not re-establish the lost soils. Since these repairs usually make tillable badly depleted soils that are highly susceptible to erosion, it is essential to check splashing raindrops as well. The usual contouring operations which control the scour process may eliminate gullying, and to a limited extent reduce rates of sheet erosion. But they do not fully check sheet erosion processes, nor do they protect soils against the damage of fertility and puddle erosion. Because of this oversight, many of the gully-filling projects now in progress will exploit the soil rather than conserve it.

History records many great conservation movements, most of which have failed in the long run. Recent splash erosion studies reveal a plausible explanation for some of these failures. The conservationists did only part of the job. They recognized and controlled the scour erosion process caused by the runoff, but failed to reckon with the most destructive process of all—splash erosion. Even today we rely entirely too much on contouring operations and we take too much pride in the beauty of fields whose rows bend with the contours, but where bare soil between these

rows betrays careless soil and water management practices.

Farmers and ranchers have long known that cover was beneficial in conserving soil and water. But the specific protective values of different covers and the protective requirements of different soils were unknown. About the only cover evaluations made in the past related to the effects of cover on reducing soil loss. Such experiments do not apply to flat lands, where soil loss is often unimportant. Even on rolling lands they have limited application. For example, an area may be well protected with a crop cover, so that there will be no puddle, fertility, or sheet erosion damages. Yet a single gully may cause great soil loss. In contrast to this situation, other fields may have very little cover protection, resulting in high puddle, fertility, and sheet erosion damages but no important soil tonnage losses from the land. It is wrong to assume that soil loss measured in the runoff water is always proportional to erosional damage on these fields. Soil loss carried in the runoff actually bears no fixed relationship to puddle, fertility, and sheet erosion damage. It is, however, a fairly sensitive measure of the damage caused by scour erosion as it carves gullies. Because of this, our present-day conservation practices are very effective for scour erosion control purposes, but they are not fully adequate for purposes of controlling the splash erosion process.

The effects of processes that are inconspicuous and seldom seen are apt to be underestimated. For more than five thousand years we have concentrated our research efforts on the erosion caused by runoff, while neglecting to develop a physical science for an attack on the problems of erosion by raindrops. But it is the raindrops we must control first of all to achieve effective and lasting results in protecting the land.

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Edward Lee Thorndike: 1874-1949

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RESIDENT of the American Association for the Advancement of Science in 1934, Edward Thorndike had been a leader in psychology since 1898 when, after his undergraduate course at Wesleyan University and his graduate study at Harvard and Columbia, he obtained the Ph.D. from the latter institution with a dissertation entitled "Animal Intelligence." This paper proved to be immensely significant in two ways. As the pioneer laboratory study of animal learning it inaugurated one of the major psychological enterprises of the present century, for he found, as his numerous successors have continued to find, that animal behavior under experimental conditions can shed light on many difficult questions in psychology. Thorndike in this first paper of his also reached a significant conclusion, a new law of learning, additional to the old laws of association and perhaps more important than any of them. This famous "law of effect," while challenged by many of his early contemporaries, has generated a vast amount of research and has gained increasing acceptance in recent decades. The "effect" in question is the success or failure of an act, the immediate satisfaction or dissatisfaction it gives its doer. As Thorndike used to phrase it, the law stated that a satisfactory outcome of any response to a situation operated to "stamp in" its connection with that situation, while an unsatisfactory outcome tended to "stamp it out." So the unsuccessful responses were eliminated, often only gradually, and the successful responses retained.

For a single year after receiving his degree Thorndike taught at Western Reserve, but in 1899 he returned to Columbia and was assigned the task of developing a scientific educational psychology at Teachers College; and there he remained for the rest of his career. He brought to this work a firm conviction of the value of the experimental method as applied to problems of learning and teaching. The law of effect was directly applicable. Mere repetitions drill would be relatively ineffective. The child should get satisfaction from his correct responses, and his tasks should be such as would enlist his interest and arouse a zeal for achievement. On the strength of some of his experiments Thorndike rejected the then current doctrine of "formal discipline" which held that the educational value of a school subject lay in the exercise it afforded for some one or more of the mental

faculties, such as the faculty of reasoning in the case of geometry. The experiments indicated, on the contrary, that the ability developed in one line of work was specific and did not spread to other lines of work except so far as what was learned could be carried over and utilized. Accordingly, he urged that school subjects should be valuable for their content and not merely as drill exercises. He applied this criterion to the detailed content of each school subject and to the curriculum as a whole. By experimental studies of children's specific difficulties in reading, arithmetic, and other subjects, he worked out procedures for meeting the child on his own ground and for individualizing education.

Besides the experimental method, Thorndike brought to the science of education a full appreciation of the value of measurement and statistical analysis. He was the great pioneer in the use of statistics in education. The correlational method, then newly developed, he found especially useful. Without being a highly trained mathematician he possessed a keen sense for realities and probabilities. These qualities appeared in his numerous studies of concrete statistical problems and in his *Mental and Social Measurements* (1904), a textbook which won many converts to this line of work. His own students also became powerful promoters of measurement in education—measurement of the individual child's capacities and readiness for school subjects, measurement of the child's progress, and measurements of the effectiveness of teaching.

Thorndike was especially active in the invention and improvement of psychological tests. He insisted on the need for tests scaled in equal units and based, if possible, on an absolute zero of achievement in each kind of ability. He worked out scales of achievement in arithmetic, handwriting, English composition, etc., so that the pupil's true progress could be known, rather than merely his relative standing in his school class. He used his improved test methods in researches on the influence of heredity and environment and on the growth of intellect up through adolescence and its slow decline after the peak in early adult life. A series of investigations convinced him of the great importance of heredity as a cause of individual differences, but also of the importance of education as a means of raising the general level of achievement and of enabling the superior individuals to make their due contribution to the world's work.

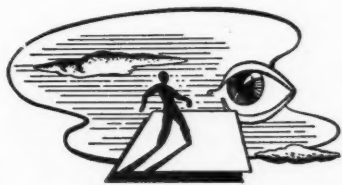
Thorndike was unwilling to admit any limits to the scope of quantitative science. As he said in 1918, "All that exists, exists in some amount and can be measured"; or, as he said in 1940, "Any want or satisfaction which exists at all exists in some amount and is therefore measurable, how exactly . . . we cannot tell until we have tried" (*Human Nature and the Social Order*, p. 152). In the book just quoted and in his AAAS presidential address, he insisted that values, being dependent on human wants and interests, were facts of nature and therefore belonged within the field of natural science, though the measurement of social values might prove to be a very complicated undertaking. He attempted with some success to apply his methods and psychological results to the study of values and social problems.

From 1921 on, he was enabled to devote his time to large scale investigations in the Institute of Educational Research at Teachers College, with assistance provided by grants from foundations. For the most part he was now free to choose his fields of work, and he chose a fundamental investigation of mental measurement and of learning. These extensive studies he regarded as quite the best work of his life. Under the head of intellectual ability, he and his collaborators worked out a remarkably thorough series of graded tests. On the basis of correlations, lower and higher, he recognized three main directions of intellectual development: abstract intelligence or the ability to deal with ideas, mechanical intelligence or the ability to deal with concrete things, and social intelligence or the ability to deal with people. He also distinguished three dimensions of any intellectual ability: the level of difficulty which one can master, the range or variety of tasks at any level which one can handle, and the speed of work.

In his later studies of the fundamentals of learning he subjected his early theory to a very careful check on the basis of a whole array of novel experi-

ments. The law of effect he now found abundantly confirmed on the positive side but subject to an important restriction on the negative side. The "stamping in" of successful or rewarded responses was fully as important as he had ever believed, but the "stamping out" of unsatisfying or punished responses was a much less potent factor in the learning process. In his later applications of learning theory to educational and social problems, accordingly, Thorndike laid much more stress on rewards than on punishments. "Except when and as it causes the person to shift to the right behavior and receive a reward therefor, the punishment has no beneficial effect comparable to the strengthening by a reward. . . . Psychology emphasizes the importance of making a community attractive to the able and good rather than unpleasant for those who are incompetent and vicious" (*Human Nature and the Social Order*, pp. 200, 202).

Thorndike was a prodigious worker and he continued his research activity to the very last. He was a rapid worker, quick to see the possibilities in a problem and select a first line of attack, willing to shift his attack as he got further into the problem, persistent in following up his leads, prompt in coming through with a published result. He disliked unfinished jobs, and his very extensive bibliography is evidence of a vast number of scientific tasks undertaken and made to yield worth-while results. As a teacher and research director he always had the interests of his subordinates at heart and was eager to give all due credit to his devoted assistants. As a colleague, collaborator, and committee member he was always responsive to the call of duty and contributed mightily to many joint enterprises. What he disliked was mere discussion, pedantry of any sort, or unnecessary work. He was a notable example of "the able and good" and in his college, his private study, his home, and his circle of friends he furnished a fine example of the good life and the happy life.



Technical Papers

A Light Polarization Analyzer in the Compound Eye of Limulus

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Experiments currently in progress indicate that the lateral eye of limulus (*Xiphosura polyphemus* [L.]) can detect the plane of polarization of a stimulating light. The quantitative study of this phenomenon has advanced to a point that warrants a preliminary report. Furthermore, such an account seems desirable in view of recent widespread interest in the use of sky polarization as a light compass by the honeybee (3, 4; reviewed in 10). The present limulus experiments may indeed, by contributing to the pertinent knowledge of the arthropod compound eye, provide a clue to the specific sensory mechanisms involved in this aspect of insect navigation (for a discussion of insect flight instruments, see 11).

Single photoreceptor units of the limulus eye have been extensively used to study the general physiological properties of visual elements by Hartline and his co-workers (for review see 6). Their results clearly show that the response to stimulation of these light receptors is closely comparable to that of other sensory units whose electrical response has been isolated (e.g. 1, 5, 7, 8). In several types of such sensory elements, including the limulus visual unit, an initial series of transients associated with the onset of stimulation is succeeded by a steady rate of sensory nerve discharge which continues as long as the specific stimulus lasts. This uniform rate of discharge varies with the intensity of the stimulus. In a range of medium light intensities, the frequency of sensory impulses changes linearly with log I. For the present experiments it was this "steady state" discharge frequency that was utilized as a measure of stimulus effectiveness.

Lateral eyes of small limulus (cephalothorax about 50 mm in length) were prepared by excising the organ along with some of the surrounding carapace and a 20-30-mm length of intact optic nerve. Then, under a dissecting microscope, the ophthalmic artery which sheaths the optic nerve, was carefully cut away. Connective tissue and other extraneous material were also cleaned from the inner side of the retina. At this point the medial aspect of the whole structure appeared as in Fig. 1. Note that just anterior to the lateral eye the optic nerve divides, usually into two rami, one dorsal, the other ventral. In turn, each of these rami provides a nerve branch to the white body which constitutes the so-called rudimentary eye.

With the carapace around the eye fixed in a clamp, the nerve was extended and held under slight tension by lightly weighting a thread tied around its cut end.

Next the nerve was split into successively finer bundles of fibers with the aid of glass needles. This was done with the nerve under sea water, which was the physiological saline used throughout. To record the electrical activity of the small bundles, they were lifted into air or mineral oil by a pair of recording electrodes held in a micromanipulator. The electrodes, made of fine silver wire, were connected to the input of a condenser-coupled three-stage amplifier, which in turn drove an oscilloscope and, through an audioamplifier, a loudspeaker.

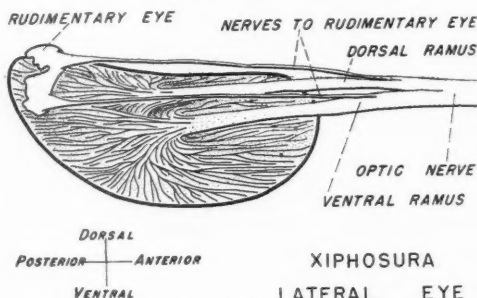


FIG. 1. Compound eye of a young limulus, medial aspect $\times 10$. Blood vessels, digestive gland, and connective tissue dissected away. Branching nervous elements covering inner surface of retina are bundles of nerve fibers. Whether branching occurs in individual fibers is not known.

The sensory elements corresponding to any given bundle of optic nerve fibers were localized by exploring the ommatidia of the eye with a fine pin point of light directed onto the corneal surface. Then, by a combination of further fiber isolation and selective photic excitation, a physiologically unitary response could usually be obtained. Such a system was essentially a Hartline single-element receptor preparation.

When a successful isolation had been accomplished in this fashion, the visual unit was stimulated by a beam of linearly polarized light whose plane of polarization could be conveniently rotated. This was obtained with a Polaroid filter interpolated between the light source, a tungsten projection bulb in an ordinary microscope lamp, and the limulus eye. The light transmitted by the filter is rated at 99.8% polarization through most of the range within the visible spectrum.

The discharge rate of the single photoreceptor element was examined as a function of the stimulating light's plane of polarization. In general, it has been found that the sensory impulse frequency varies systematically with the change in the plane of polarization. Maximum and minimum response rates occurred with polarization planes 90° apart. Two complete cycles appeared during a 360° rotation of the polarizer.

The following experiment will serve to illustrate the quantitative relation between the two factors, nerve

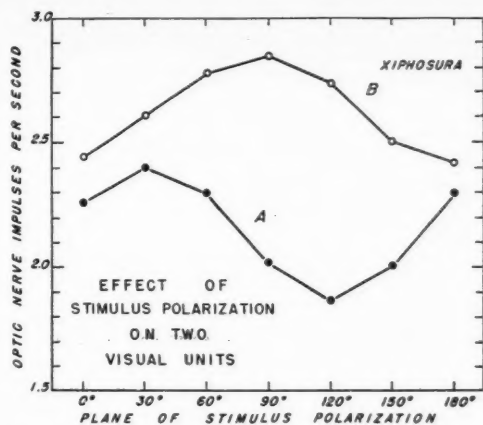


FIG. 2. Relation between optic nerve impulse frequency and polarization plane of the stimulating light for two different isolated photoreceptor units in the same limulus lateral eye. Each point is the mean of 10 frequency measurements. Retinal location of the units, A and B, is shown in Fig. 3.

impulse frequency and polarization plane of the stimulus. In making these actual rate measurements the intensity of the stimulating light was reduced, so that steady-state nerve discharge rates of 2-3 per sec were obtained. Their frequency was determined by measuring with a stop watch the time interval required for 25 discharges. Measurements were made for 7 planes of polarization, 30° apart, between 0° and 180°. To counterbalance drift in the physiological state of the preparation and to minimize the effect of its adaptation, 10 readings for each point were obtained by testing each position serially from 0° to 180°, then in reverse order from 180° to 0°, and so on until sufficient data were collected.

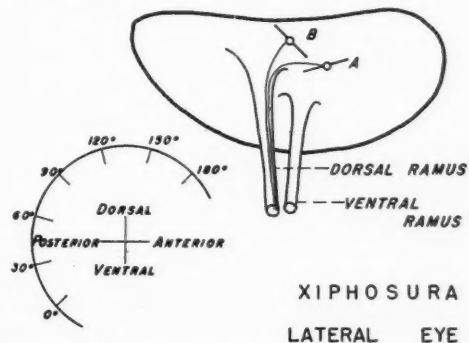


FIG. 3. Medial diagrammatic view of limulus lateral eye used to obtain data of Fig. 2. Optic nerve ramus stretched medially as during the experiment. Photoreceptor elements A and B are symbolized by circles, the alignment of their polarization analyzers by lines through the circles. Relative orientation of these ocular structures to the whole animal and to the scale measuring polarization angle shown at left.

Response curves secured in this way for two visual elements from the same limulus eye are plotted in Fig. 2. The location of the particular units concerned in the retina and in the optic nerve appears in Fig. 3. Note that the frequency of impulses in the optic nerve fibers varied 15% and 23%, respectively, for the two units, between the maxima and minima caused by rotating the polarization plane of the stimulating light. The resulting curves appear as smooth periodic functions with a wavelength of 180°.

Statistical analysis of the 70 raw scores used in plotting each of the mean curves in Fig. 2 shows that the differences in the means due to changes in the plane of polarization are highly significant. Analysis of variance in these data has been carried out and the reliability of the differences determined in the usual way from an F table. In both cases F values for the plane of polarization considerably exceed those required for significance at the 1% level.

Three independent lines of evidence have been examined to ascertain that the effect described is significant not only in a statistical sense but in a physiological sense as well. First, the possibility that polarization of the light source caused actual intensity fluctuations in the stimulating light was considered. This was checked initially by determining whether intensity changes detectable to the human eye were caused by rotation of the polarizing filter. Such changes were not present either in the total light transmitted by the polarizer or in the minute image of the light source focused on the limulus eye. As another check no significant changes appeared in the response curves when the stimulating light was rotated through 90° during an experiment. These facts would apparently eliminate the light source as a possible cause of the observed effect.

Second, the stimulating light and all other extra-ocular factors seem to be excluded by the following type of experiment. If the polarization analyzer effecting the response curves described is actually in the biological system, rotation of the eye through a given angle should produce a corresponding angular displacement in the response curves obtained in the usual way. The results of such a test are shown in Fig. 4. They demonstrate that within the limits of experimental error an identical displacement of the polarization curves was effected by a rotary change in the eye's position. Third, the data in Fig. 2 also suggest that instrumental artifacts are not responsible for the experimental results. They indicate that under similar experimental conditions two sensory elements, even though fairly close together on the same retina (Fig. 3), elicited response curves which were 60° out of phase.

The foregoing data prove that at least under specific conditions, a polarization analyzer is present in the compound eye of *Xiphosura*. It may thus be concluded that for this photoreceptor significant differences in the "apparent brightness" of a stimulating light depend on the plane of its polarization. A number of critical experiments remain to be done before the biological importance of this phenomenon can be assessed.

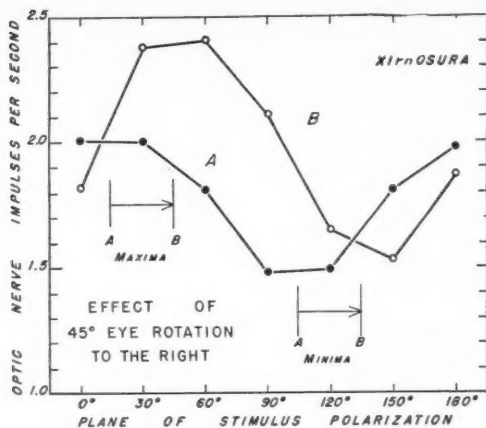


FIG. 4. Control data demonstrating that the polarization effect observed is a function of the biological system. After measurements were made as in previous experiments (A), the limulus eye itself was rotated clockwise through 45° and a second series of measurements taken. Corresponding displacements of both maxima and minima of the response curve occurred.

First, a quantitative study should be made to determine the extent of this effect through the full ranges of intensity and wavelength to which this visual system is sensitive. Then an analytical search should be instituted to discover the structures constituting the polarization analyzer involved. Some clues for such research should be sought in the studies of polarization optics of biological materials in general (9) and of eyes in particular (2). The dioptric properties of the limulus eye and possible birefringence of various of its elements, including the retinula cells, clearly should be investigated in this connection. Third, the behavior of *Xiphosura* should be examined to see whether polarized light has any normal functional significance for this arthropod. Finally the possible relationship of the present observations to von Frisch's work on bees, mentioned in the introduction, should be worked out. Particularly pertinent here would be the determination of the over-all pattern of sensitivity and orientation of the individual polarization analyzers in the whole retina. In the solution of the various structural and functional problems involved here, one may expect to find answers to certain of the specific questions asked, but one may also confidently expect in the process to learn much that will contribute toward our broad understanding of the compound eye.

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The Combined Action of Penicillin with Streptomycin or Chloromycetin on Enterococci *in Vitro*¹

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Synergistic effects have been demonstrated with a number of chemotherapeutic agents (1, 2, 6-10). A synergistic effect of penicillin-streptomycin mixtures *in vitro* against certain staphylococci and a hemolytic streptococcus has been reported by Nichols (8). The combined action was greater than a simple additive effect of the drugs but the synergism was of low order. Clinical reports (4, 11, 13) indicate that combined therapy with penicillin and streptomycin is often successful in curing bacterial endocarditis due to enterococci, which ordinarily fails to respond to either drug alone, even when administered in high dose over a long period. With enterococci it has been shown (5) that mixtures of penicillin and streptomycin *in vitro* rapidly brought about death of the entire bacterial population, whereas streptomycin alone had no effect, and penicillin alone had mainly bacteriostatic properties. The experiments presented here may add to the understanding of this antibiotic synergism. In the course of our studies it was also noted that Chloromycetin² interfered with the action of penicillin on many strains of enterococci *in vitro*. This drug was therefore included in these experiments to compare streptomycin-penicillin synergism with apparent Chloromycetin-penicillin antagonism.

The bacteriological culture media used were Proteose-Peptone #3 agar (Difco) and a broth having the same base. Crystalline Sodium Penicillin G, Streptomycin sulfate, and Chloromycetin (Rx 117344) were dissolved in sterile saline. The Chloromycetin solution was sterilized by Seitz filtration. Final dilutions of the drugs were made in broth in a total volume of 20 ml. The bacterial inoculum consisted of 1 ml of an 18-hr broth culture containing 10^8 - 10^9 organisms/ml. All cultures were incubated at 37° C. At intervals aliquots were removed from the test mixtures, and the number of viable organisms determined by serial dilution and plate count. In other aliquots the penicillin was inactivated with penicillinase (Bacto-Penase) in order to permit penicillin-inhibited bacteria to grow. Absence of growth after the addition of penicillinase was interpreted as absence of

¹ Supported in part by a grant from the Research Committee of the University of California Medical School.

² Commercial brand of chloramphenicol. Generous supplies of this drug were kindly made available by Dr. G. Rieveschl, Parke Davis and Company, Detroit, Michigan.

viable bacteria. Nine strains of enterococci were studied. The organisms were isolated from the blood stream or urinary tract of patients and corresponded to the description given by Sherman (12). The strain² most extensively studied (#16), shown in Fig. 1, originated in a patient with subacute bacterial endocarditis subsequently cured by combined penicillin-streptomycin therapy.

The results observed with 9 strains of enterococci were fairly uniform and are represented by the experiment shown in Fig. 1. The numbers of viable enterococci in populations exposed to penicillin (6 $\mu\text{g}/\text{ml}$), streptomycin (25 $\mu\text{g}/\text{ml}$), Chloromycetin (10 $\mu\text{g}/\text{ml}$), or combinations of these drugs, are plotted against time of incubation.

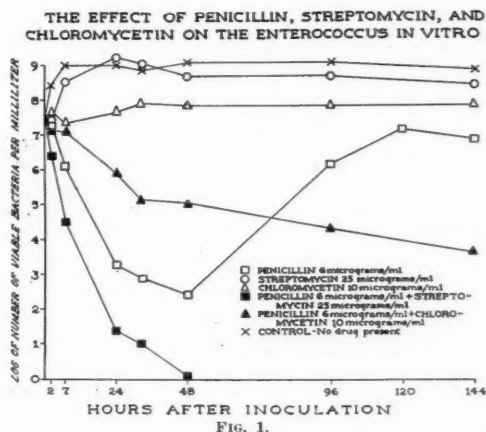
The concentration of penicillin used (6 $\mu\text{g}/\text{ml}$) falls into the "optimal zone" (3, 5) for this enterococcus

cillin usually produced complete sterilization of the medium; within 3 to 5 days all enterococci were non-viable, failing to grow in subculture even after adequate amounts of penicillinase had been added.

The combined effect of streptomycin and penicillin on enterococci is evidently more than a summation of the individual drug effects. In the concentrations used, streptomycin alone had no demonstrable action whatever on these bacteria. The concentration of penicillin was in the "optimal zone" of the drug for the particular organism, i.e., the bactericidal rate was greater at 6 $\mu\text{g}/\text{ml}$ than at 3, 15, 30, or 300 $\mu\text{g}/\text{ml}$. Thus in terms of bactericidal rate, penicillin action alone was already at an optimum which could not be increased by raising the concentrations of that drug. Hence, the increased effect of penicillin-streptomycin mixtures must be a true synergism of the two drugs. Likewise, in terms of the rapid sterilization of the medium by streptomycin-penicillin combinations, the effect is not merely a summation of individual drug actions. Streptomycin alone, in concentrations of 25 to 500 $\mu\text{g}/\text{ml}$, even after long incubation at 37° C, does not kill the entire bacterial population, penicillin alone in concentrations 5 to 50 times greater than that used here sometimes killed all exposed organisms, but only after incubation periods exceeding 5 to 7 days at 37° C. The rapid death of the entire enterococcal population exposed to streptomycin-penicillin mixtures indicates a considerable (at least tenfold) potentiation of penicillin action. This rapid sterilization might be a function of the greatly accelerated rate of bactericidal action.

The questions naturally arise whether the few enterococci remaining viable after exposure to 6 $\mu\text{g}/\text{ml}$ of penicillin alone for 24 hr represent resistant mutants, and whether their subsequent multiplication at a normal rate is due to such resistance. If that were the case, the effect of streptomycin-penicillin mixtures might be explained on the basis of inhibition of penicillin-resistant forms by another antibiotic. To test this hypothesis, organisms were removed from penicillin action by adding penicillinase to the medium after most of the bacterial population had become nonviable. Sensitivity tests performed with such organisms indicated no increase in their penicillin resistance over that of the original population. Furthermore, there is to date no indication that these organisms are more susceptible to the action of streptomycin than the original population. Thus the main demonstrable effect of streptomycin-penicillin synergism on enterococci appears to be the increase in rate of bactericidal action beyond the optimum obtainable with penicillin alone.

Chloromycetin (10 $\mu\text{g}/\text{ml}$) alone had no significant effect on the bacterial population (Fig. 1). However, when mixed with 6 $\mu\text{g}/\text{ml}$ of penicillin this concentration of Chloromycetin had a notable effect. The rate of bactericidal action was less than with penicillin alone. The low number of viable bacteria attained with penicillin alone in 24 hr was not reached with the Chloromycetin-penicillin mixture until the 6th to 12th day. Thus it appeared that Chloromycetin somehow interfered with the



strain and results in a maximal bactericidal rate. Lower concentrations produce only slight bacteriostasis, whereas concentrations greater than 15 $\mu\text{g}/\text{ml}$ have a much reduced rate of bactericidal action. It is seen in Fig. 1 that with 6 $\mu\text{g}/\text{ml}$ of penicillin the count of viable bacteria rapidly decreased to low levels. However, the number of bacteria did not reach zero but after an additional 24 to 48 hr the population again increased and remained for at least 10 days at levels somewhat below those of the controls without drug. With higher concentrations of penicillin, (e.g., 300 $\mu\text{g}/\text{ml}$) the decrease in viable bacteria occurred more slowly and again not all bacteria were killed in 7 to 10 days.

Streptomycin in concentrations of 25 to 50 $\mu\text{g}/\text{ml}$ completely failed to inhibit the large bacterial inocula used in these experiments. When these amounts of streptomycin were added to penicillin, two striking effects were noted: a) The rate of bactericidal action was greater than with penicillin alone. This increase in rate was observed with concentrations of penicillin from 6 to 300 $\mu\text{g}/\text{ml}$ and concentrations of streptomycin of 25 to 100 $\mu\text{g}/\text{ml}$. b) The mixture of streptomycin and peni-

² Dr. L. A. Rantz kindly supplied this organism. (13)

early bactericidal effects of penicillin on enterococci, i.e., had some antagonistic action to that of penicillin. This lowering of the rate of bactericidal action occurred in combinations of Chloromycetin (10 $\mu\text{g}/\text{ml}$) with a wide range of concentrations of penicillin (6 to 60 $\mu\text{g}/\text{ml}$). This interference phenomenon was observed with all nine strains of enterococci but not always to the same degree.

Another observation should be noted: Whereas penicillin (6 $\mu\text{g}/\text{ml}$) alone permitted a great increase in the numbers of viable bacteria after the original sharp decline (Fig. 1), Chloromycetin-penicillin mixtures resulted in a slow but steady decrease of the population. Thus the late effects of this antibiotic mixture resembled those of high concentrations of penicillin (e.g., 300 $\mu\text{g}/\text{ml}$) alone, far outside the optimal zone. In both instances the number of viable bacteria diminished more slowly than at the optimal concentration of penicillin alone (6 $\mu\text{g}/\text{ml}$) but after long periods of incubation occasionally all enterococci succumbed.

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Cytologic Demonstration of Nucleic Acids in Tissue Culture¹

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The tissue culture technique offers a means of investigating a great variety of biochemical and physiologic processes such as the nutritional requirements of the various cell types (6, 15), the action of drugs and other chemicals on growing tissue (12), the nature of various metabolic reactions and other biochemical changes in the medium (7, 8), and many other vital manifestations of growth phenomena (9).

The authors' interest in nucleic acid metabolism and the effect of nucleic acid inhibitors on growth and their

relation to protein synthesis suggested the possibility of using tissue culture techniques in these investigations. It has been shown recently (5) that cells grown *in vitro* may be analyzed biochemically for desoxyribonucleic (DNA) and ribonucleic (RNA) acids, and that cytochemical methods are available for the demonstration of the presence of these nucleic acids in fixed sections of tissue culture. The following procedures have proved successful in demonstrating nucleic acids in cells grown *in vitro*.

The classical double cover slip technique of Maximow was used. Tissue (chick embryo muscle) was cut into small fragments (1 mm³), embedded in a medium composed of equal parts of 50% chick embryo extract and rooster plasma,³ incubated at 37° C for 72 hr, and fixed.

The following three fixatives were used: Cowdry's—equal parts saturated aqueous solution of mercuric chloride and 95% ethyl alcohol for 3 hr. Carnoy's—acetic acid-alcohol (1:3) for 1 hr. Serra's—alcohol-formol-acetic acid (6:3:0.5) for 3 hr. Although Carnoy's and Serra's are not ideal fixatives, nevertheless they preserve nucleic acids well and permit excellent staining (2).

The cover slip preparations were washed thoroughly in running water after fixation in Cowdry's and Serra's fluids, and washed in descending strengths of alcohol after Carnoy's. They were rinsed in distilled water and dried slowly in air (4). This drying technique has proved very successful in eliminating the opacity produced in the plasma coagulum by fixation.

The basic dyes, methyl green and pyronin, have been shown to be specific for the two nucleic acids DNA and RNA (1, 10). By employing these stains in conjunction with specific enzyme digestion (desoxyribonuclease and ribonuclease), it is possible further to identify these acids. The Feulgen reaction was also used to demonstrate the presence of DNA.

Staining solutions used were:

Methyl green ⁴ (Grübler or National Aniline)	0.15 g
Pyronin (Grübler or Eastman)	0.25 g
Ethyl alcohol, 95%	2.5 ml
Glycerine, C. P.	20.0 ml
Carbolic acid-water (0.5%)	77.5 ml

The method of staining used was as follows: The cover slip preparations were stained in dye solutions for 20–30 min. They were rinsed in distilled water, blotted with filter paper, differentiated and dehydrated in tertiary butyl alcohol for 1–3 hr, then cleared in xylol and mounted in elarite. By this method, chromatin is stained green, nucleoli and cytoplasm red.

In studying enzyme digestion of desoxyribonuclease,⁵

² The lyophilized embryo extract and plasma were kindly furnished by Dr. C. W. Christensen of Difco Laboratories, Inc., Detroit, Michigan.

⁴ This dye contains a small amount of a violet compound which stains nonspecifically and must be removed. To achieve this, the chloroform purification method described by Pollister (11) was used.

⁵ The desoxyribonuclease and ribonuclease were obtained commercially from Worthington Biochemical Laboratory, Freehold, New Jersey.

¹ Supported in part by a grant from the Iowa Division, American Cancer Society.

² Research Fellow in Medicine, American College of Physicians, 1949–1950.

the crystalline enzyme was dissolved in triple-distilled water to give a concentration of 0.2 mg/ml. Magnesium sulfate was added to a final concentration of $M/100$, and gelatin, as a protective colloid, to a concentration of 0.01%. Ribonuclease the crystalline enzyme, was dissolved in triple-distilled water to a concentration of 0.2 mg/ml.

Three cover slip preparations were used. One specimen was placed in the desoxyribonuclease solution for 1 hr at 37° C, the second in the ribonuclease solution for 1 hr at 37° C, and the third, the control, in distilled water for the same period of time and at the same temperature. The specimens were then rinsed in distilled water and stained with methyl-green-pyronin as described. The Feulgen reaction may also be used to demonstrate DNA.

The results of desoxyribonuclease digestion are: Nucleolus and cytoplasm stain red, chromatin does not stain. The Feulgen test is negative, showing the absence of DNA. In ribonuclease digestion: chromatin stains green, nucleolus and cytoplasm are unstained.

It has been shown that nucleic acids can be extracted quantitatively by heating in 0.3 M trichloroacetic acid (10). The application of this technique to cytologic preparations without destroying the cellular architecture has been reported (19). This method proved successful in tissue culture preparations by using the following procedure:

1. Place cover slip preparations in 0.3 M trichloroacetic acid at 90° C for 5–10 min.
2. Rinse in three changes of distilled water.
3. Stain with methyl-green-pyronin or Feulgen reagents.

Since the nucleic acids are removed, the cells remain unstained and are Feulgen-negative.

The methods described provide techniques whereby RNA and DNA can be demonstrated in cells grown *in vitro*. These methods can be put on a semiquantitative basis by measuring the absorption at 2600 Å with the ultraviolet microspectrophotometer (3, 13), or extinction with the photomultiplier tube photometer (14).

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Synthesis of 1-C¹⁴-L-Ascorbic Acid

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To make possible an extension of research under way, dealing with the biological functions of L-ascorbic acid in the tissues of guinea pigs and albino rats, it was necessary to have available 1-C¹⁴-L-ascorbic acid. The ascorbic acid thus labeled has been synthesized by a modification of the methods of Ault *et al.* (1) and Reichstein *et al.* (3, 4).

The steps involved cyanide addition to L-xylosone,² carried out under conditions to insure the maximum yield based on the labeled sodium cyanide. Forty-nine mg of sodium cyanide (1.0 millimole) which contained approximately 1 millicurie (mc) of C¹⁴ was added to 155 mg of L-xylosone (1.05 millimole) in 19 ml of water adjusted to pH 6.5. The addition of cyanide as shown by titration of the imino-L-ascorbic acid was 95% of the theoretical value. An additional 18 mg of sodium cyanide (0.37 millimole) was added to react with excess L-xylosone which, if not removed, interferes with final crystallization of the L-ascorbic acid.

The resulting imino-L-ascorbic acid was hydrolyzed to L-ascorbic acid in 2.6N HCl at 50° C for 22 hr. The radioactive carbon dioxide arising in part from decarboxylation of L-ascorbic acid was collected in saturated barium hydroxide solution. In pilot runs, the amount of barium carbonate formed was equivalent to the 15%–20% of ascorbic acid lost during hydrolysis.

The L-ascorbic acid was purified from mineral salts and other impurities by employing an ion-exchange column technique similar to that used in isolating the 2,4-dinitrophenyl-osazone derivative of L-ascorbic acid from the urine of the rat (2). An Amberlite IR-100 column was used to remove all cations which would prevent the adsorption of ascorbic acid on the Amberlite IR-4-B column. Impurities less acidic than ascorbic acid were preferentially eluted by 4% acetic acid prior to elution of ascorbic acid with 1N HCl.

The eluate from the anion column was evaporated to a syrup *in vacuo* under nitrogen, taken up in 15 ml of absolute alcohol, and further purified through an alcohol-ether fractionation. The final product was obtained in good yield as colorless crystals from methanol-ether-ligroin solvent mixture at –15° C.

In the radioactive synthesis, 180 mg of L-ascorbic acid was obtained which contained approximately 75% of carrier ascorbic acid added to facilitate crystallization in the course of the synthesis. This represented a final yield of approximately 25% based on the labeled sodium cyanide. The L-ascorbic acid had an activity of 2.10×10^6 cpm/mg.

¹ This investigation was aided by grants from the Nutrition Foundation, the National Institutes of Health, U. S. Public Health Service; and the Hoffman-La Roche Co.

² Prepared from L-xylose kindly supplied by Dr. Robert Hockett of the Sugar Research Foundation.

L-Ascorbic acid obtained in trial runs was 99.7% pure by indophenol titration and had a melting point of 189–191° C (cor.). Analysis of the inactive L-ascorbic acid gave the data:

Calculated:	C 40.91,	H 4.55;
Found:	C 41.06,	H 4.61.

Additional details regarding the preparation, administration, and end products of the substance will be given in another paper.

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Sterile Pieces of Chick Embryo as a Medium for the Indefinite Axenic Cultivation of *Rhabditis briggsae* Dougherty and Nigon, 1949 (Nematoda: Rhabditidae)

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During the past eight months (i.e., since December, 1948) it has been possible to rear successive generations of a rhabditid nematode, *Rhabditis briggsae*,² on sterile pieces of chick embryo. This medium may be termed "axenic"³ (without strange [life]), inasmuch as the pieces of chick embryo are nonliving. Moreover, in some cases the pieces have been frozen, thawed, and then used; in others they have undergone a certain amount of autolysis before use by reason of being stored at 4° C for up to a month's time. To date the cultures, which were originated in triplicate with streptomycin-sterilized larvae (from two-membered cultures with *Escherichia coli*) according to the technique of Dougherty and Calhoun (4, 5), have passed through four transplants and are now in their fifth; at least 12 successive generations of *R. briggsae* are thereby represented. In addition, from the third and fourth transplants larvae have been used for experimental purposes; these have passed through two additional axenic generations. Each transplant is routinely tested for sterility by inoculation of a loopful of the old culture into nutrient broth at the time of transfer.

¹ Senior Research Fellow of the American Cancer Society as recommended by the Committee on Growth of the National Research Council, 1949–52.

² This species has been incorrectly referred to as *Rhabditis elegans* Maupas, 1900, in recent publications (5, 7); it is actually a new species, the description of which is in press as this is written (6).

³ A term proposed in 1942 by Baker and Ferguson (1).

Whenever the appearance or odor of a culture has suggested contamination, further tests have been done by inoculation into 0.1% thioglycollate-0.1% dextrose-0.05% agar-peptone broth and 1% dextrose-0.5% yeast extract medium, or by Gram stain.

Although the ultimate nematode yield in chick embryo cultures is excellent, the growth rate of *R. briggsae* is definitely slower than that in two-membered cultures or in cultures with a mixed microbial flora. Nigon and Dougherty (8) have found that this species requires 4 days from egg to egg at 16° C with a mixed bacterial flora present, whereas I have observed that, at least in the initial stages of the culture, maturation takes not less than 6 days at a similar temperature on chick embryo. In the latter case, either growth factors are not available in optimal amounts, or inhibitory substances are present; or perhaps both situations obtain. Indefinite maintenance of *R. briggsae* on media containing unheated, sterile liver extract as the sole source of the essential heat-labile factor or factors, such as has been attempted for *R. pello* (5), has not yet been tried.

At present studies are being conducted in an effort to develop a chemically defined medium for *R. briggsae*. So far it has not been possible to obtain indefinite growth on any such medium. These studies will be reported in later publications.

The function of a defined medium in the case of rhabditid nematodes would be to permit, among other things, biochemical genetic studies. This problem has been discussed by Dougherty and Calhoun (3), and the advantages that these organisms offer have been stressed (2, 3). The particular importance of demonstrating that *R. briggsae* is capable of indefinite axenic growth lies in the fact that this self-fertilizing, hermaphroditic species is admirably suited on theoretical grounds to the detection of recessive autosomal mutants, particularly those involving nutritional defects. The recent production of a morphological mutant of *R. briggsae* (9), the first to be described in the Nematoda, provides evidence of the practical mutability of these forms. With the development of a completely synthetic medium, biochemical genetic studies should become possible. The problems remaining in the realization of this end are unquestionably numerous and difficult. Nevertheless, the fact that chick embryo permits indefinite axenic growth offers valuable leads toward the ultimate solution of these problems.

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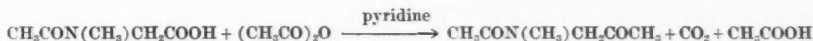
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Mechanism of the Base-catalyzed Conversion of Acylamino Acids to Acylamido Ketones

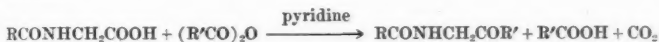
Richard H. Wiley

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Recent studies (6, 7) of the base-catalyzed reaction of



acylamino acids with acid anhydrides to form acylamido ketones



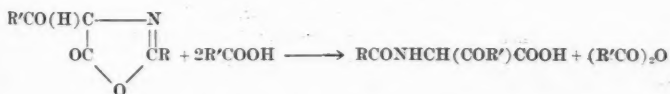
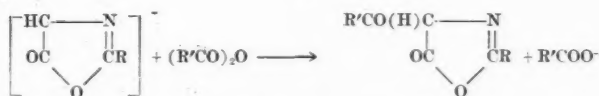
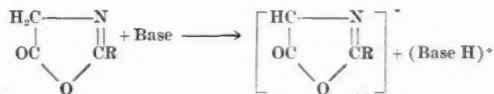
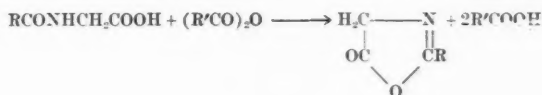
have considerably extended the utility of the reaction. Methods have been described for obtaining excellent yields of ketone with many α -acylamino acids including acetyl glycine (7) which at first was not believed to react, and many acid anhydrides including benzoic anhydride (3). It is also known that benzoyl fluoride may be substituted for the anhydride. In recent discussions of some of these discoveries (1, 3) a mechanism has been proposed for the reaction which involves acylation of an azlactone (oxazolone-5) as the essential or most likely intermediate. This mechanism is formulated as follows:

tone intermediates. The acylation step offers a tempting comparison to other base-catalyzed acylations such as the Claisen and Perkin reactions.

The purpose of this report is to comment briefly on this mechanism in light of an observation made in this laboratory (8) that acetylsarcosine reacts, under the usual conditions of time and temperature, with acetic anhydride in the presence of pyridine with evolution of carbon dioxide to form N-methylacetamidoacetone.

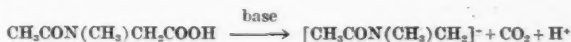
This observation clearly indicates the insufficiency of the azlactone mechanism. Cyclization of acetylsarcosine to the azlactone is prevented by substitution of N—H₂ for N—H. There is other evidence in the literature indicating that the azlactone mechanism is not sufficient, notably the report that phenylacetic acid reacts under these conditions with acetic anhydride (4).

A mechanism sufficiently comprehensive to explain this reaction is desirable and the following mechanism is accordingly suggested. The acylamino acid is first decarboxylated by the base to a carbanion. This reaction is



The first step of this mechanism is supported by the known conversion of α -amino acids to azlactones by anhydrides (2). Also, the Erlenmeyer azlactone synthesis

to be expected of a carboxylic acid carrying an electrophilic group in the beta position.



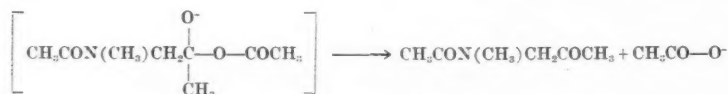
and the formation of 4-ethoxymethylene-5-oxazolones are related reactions commonly accepted as involving azla-

Both the acylamido and N-methylacylamido groups are apparently sufficiently electrophilic to promote this reac-

tion. The anion formed then adds to the carbonyl group of the anhydride (or acyl halide) to give the anion shown:



This addition carbanion then loses the acetate ion to form the ketone



or combines with a proton and loses acetic acid. The addition of a carbanion, formed by decarboxylation, to a carbonyl group has been previously observed (9).

An alternative mechanism regarded as less likely in view of the expected ease of loss of carbon dioxide, postulated as the first step in the preceding mechanism, is that the acylamino acid undergoes C-acylation as an active methylene compound. This can be visualized as proceeding through the intermediate



in which the carboxyl group may have been converted to a mixed anhydride, an anion, or an azlactone. This is merely a generalization of the previously stated azlactone mechanism. C-Acylation of active methylene compounds has long been known and is illustrated by formation of diacetoacetic ester from acetoacetic ester and

acetyl chloride in the presence of sodium (5), or by rearrangement of β -acetoxyarotonic ester (10).

The mechanism proposed indicates that the reaction is more widely applicable than has been realized. Decar-

boxylation as a source of reactive carbanions represents a class of organic reactions hitherto unappreciated.

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The Pleistocene History of the Mississippi River

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The Mississippi River throughout about half its course now flows within an area that during Pleistocene time was invaded by the lobes of four continental glaciers in succession. The first (Missourian), second (Iowan), and third (Illinoian) came from an eastern quarter (Wapello Lobes); but the later invasions of the Illinoian, and the fourth (Wisconsin) glaciation (Mankato Lobes) spread out from the north (2).

The first three of these glacier invasions each caused a large displacement of the pre-Pleistocene Mississippi, whatever may then have been its position. During the deglaciation of each of these glaciers, which took place only during the warm summer months of each year, the upper course of the Mississippi River was marginal to a glacier lobe, and it carried vast quantities of cold meltwater, as well as the meteoric water from surface streams. During the winter months, however, these channels car-

ried only the meteoric water of the surface streams, and so shrank to such moderate proportions as to expose a portion of the deposits on the bed to the fierce winds off the glacier and so yield a broad but thin surrounding apron of loess, now weathered (gumbotil).

From the Mankato lobes of the Late Illinoian and the Late Wisconsin glaciations, the periglacial land surface sloped outward, giving rise to many outward-flowing streams of meltwater that coalesced near the glacier front, and their floods formed plains of outwash, surrounding which were laid down heavy deposits of loess.

Displaced by the several glacier lobes, the courses of the marginal meltwater rivers within the states of Iowa and Missouri were as shown in Fig. 1; they are now revealed by deep trenches cut in the bedrock.

Approximately equal volumes of meltwater must have issued from the southern flanks of each of the four glaciers in southern Illinois, Indiana, and Ohio; but up to the present the courses of these streams have not been traced except in Ohio (3). The corresponding channels in Indiana and Illinois will probably be found soon by the ground-water geologists of both federal and state surveys in their now intensified search for aquifers within the region. Wherever these may later be discovered,

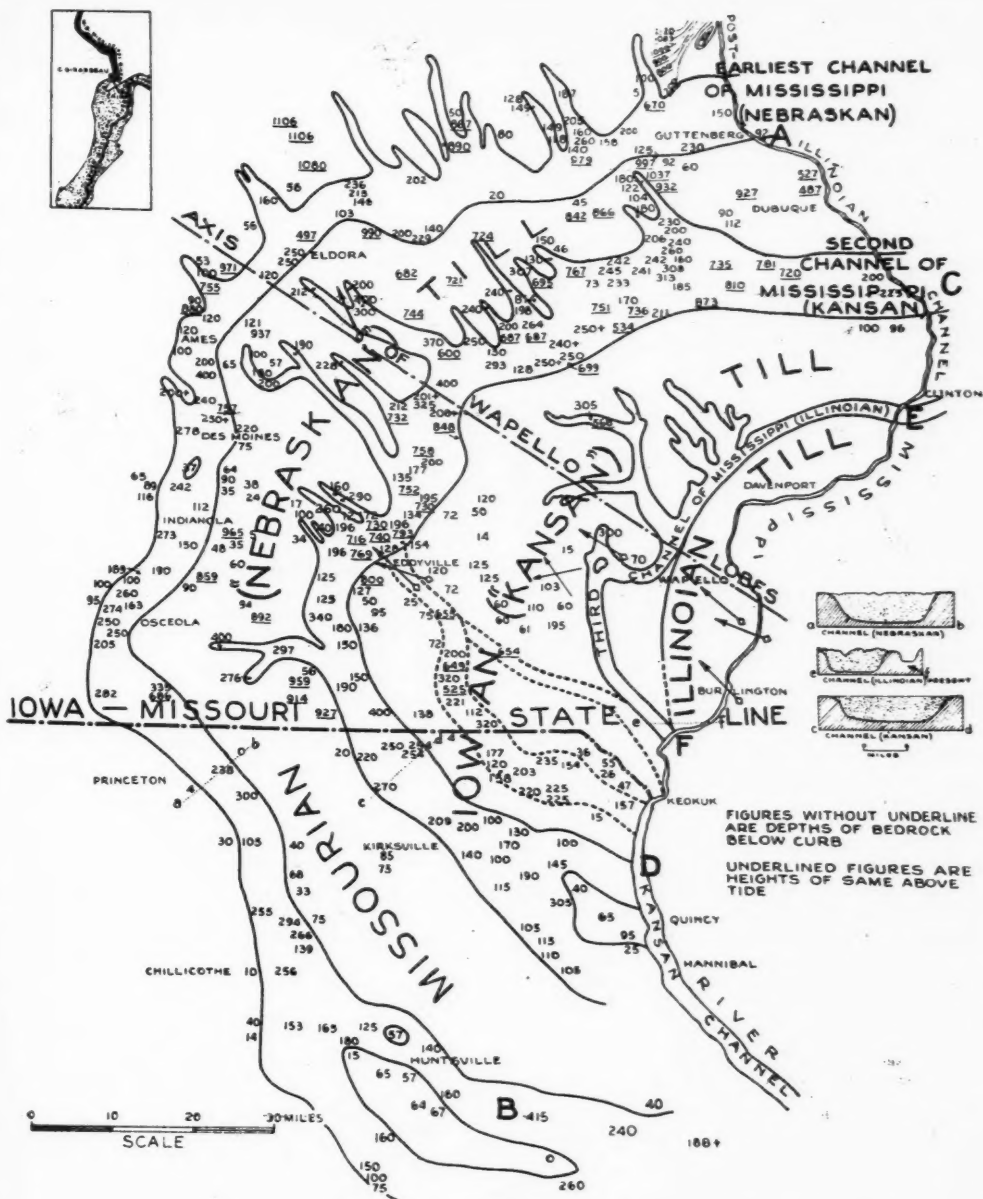


FIG. 1. Map of southeastern Iowa and northeastern Missouri to show the courses of the three meltwater rivers that bordered the three Wapello glacial lobes of the Missourian, Iowan, and early Illinoian stages during their deglaciation. Their sizes compared to the present river are indicated by the profiles at the right.

their waters must have discharged into the Mississippi near the mouth of the present Ohio River at Cairo. More than the softer beds of the Tertiary Gulf Embay-

ment, these great seasonal meltwater rivers account for the greatly increased breadth of the Pleistocene channels of the Lower Mississippi (Fig. 2). A generalized

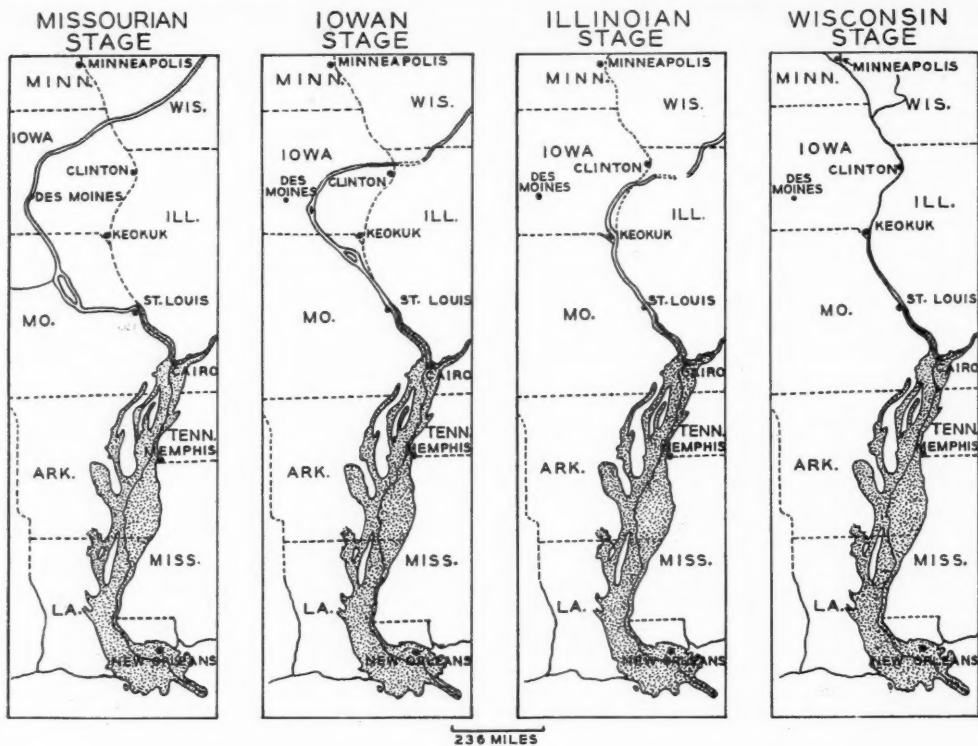


FIG. 2. Maps of the channel of the Mississippi River during each of the four stages of the Pleistocene. For the Lower Mississippi the maps by H. N. Fisk (1) have been followed.

section of the four successive channels and terraces in this lower section of the river has been supplied by Fisk (1).

The alternation of great volumes of cold summer melt-water with much reduced discharges of the Mississippi during the winter seasons throughout the Pleistocene period is confirmed by the bottom cores and oceanographic samples collected by the Woods Hole Oceanographic In-

stitution on the cruise of the *Atlantis* in February and March of 1947. Over large areas in the Gulf of Mexico off the mouth of the Mississippi were found sediments of varvelike alternations of sand, silt, and mud which were characterized by a subarctic fauna. These, the far-spread bottom-set beds of the delta, were found within one or two feet of the surface of the sea floor (4).

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Comments and Communications

Research Publication: An Addendum

Several important facts concerning publication in the field of physics have been brought to my attention since the appearance in *Science*, August 26, of the article "Research Publication: A Federal Responsibility?" In the belief that this additional information will be of interest to *Science* readers and that it is important to a fuller understanding of the publication situation in this leading scientific field, this brief addendum is made.

Physical Review. The publishers of the *Physical Review* have indicated that its situation is not as extreme as that of the *Journal of Chemical Physics*. They report that the *Physical Review* has at no time failed to publish promptly all creditable papers in the field of physics which are submitted and are proper to the journal. The accomplishment of this, to date, has been a matter of great pride to members of the American Physical Society. But it is also a great financial burden. The American Physical Society tells me that this undertaking is costing more than the society's current income can support. The society has met its publishing obligations for the past several years by using funds which it was able to accumulate during the war period. This year the *Physical Review* has managed, partly through outside aid, to keep abreast of the rising number of papers to be published. For 1950, drastic increases in dues and subscription prices have had to be decided upon without full certainty that even these will be sufficient.

Nuclear Physics journal? The suggestion made in the August 26 article that an adequate outlet in nuclear physics is not available has caused concern among the publishers of the *Physical Review*. They rightly feel that this would be too great a falling down on their responsibilities to be tolerated. Whether there should be a journal devoted exclusively to nuclear physics is a question that the managing editor of the American Physical Society and his advisers have had under consideration for some time. It is entirely possible that the step of dividing the *Physical Review* into a nuclear physics journal and a "rest of physics" journal will be taken. It is indeed understandable that there are many arguments against such a step and many for it. These have not yet been resolved. Meanwhile, the *Physical Review* should certainly be commended for having willingly accepted the great burden of providing an outlet for the increasing number of research papers in this and all other branches of physics.

The American Physical Society has excelled in an important task which must continue. That it needs help is apparent. That it is worthy of help is also apparent.

MARION A. JURGENS

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I have read the article on research publication with decided interest and agree fully with the thesis that the

government, which is appropriating such large funds these days for research work, should look to the end of the process and also provide adequate funds for publishing the results. Otherwise the research funds are largely wasted and the desired results are not obtained.

In this department we are going counter to the trend recommended and are eliminating means of disseminating scientific information. Two years ago the *Experiment Station Record*, which carried to its many readers each month the results of agricultural and biological research throughout the world, had to be suspended after 95 volumes because of a shortage of funds. This year at the end of the fiscal year in June the *Journal of Agricultural Research*, started in 1913, had to be suspended for the same reason. This journal carried only technical scientific articles on fundamental biological and agricultural research done here in the department and at the state agricultural experiment stations. I have been editorially in charge of this journal the last 25 years and I naturally regret exceedingly that its publication will not be continued. We always tried to maintain it on a high scientific and editorial plane and our efforts have apparently borne fruit. We have received many commendatory letters from research workers in this and other countries on its high quality. These have made us feel that our work was appreciated but they only added to the regret we have in seeing the journal discontinued. But such instrumentalities for the dissemination of scientific information must have financial support if they are to accomplish their functions. I therefore think that Miss Jurgens is on the right track in indicating the responsibility of the government in attaining desired objectives.

As I see the picture, those authorized to handle government budgets and make appropriations for approved projects will sooner or later be forced to give more attention to official channels of scientific publication.

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Catching Fishes with the Hand in India

On reading E. W. Gudger's article (*Amer. Naturalist*, 1948, 82, 281) "Catching Fishes with the Hand. I. In the Two Americas," and on learning from him that no records of this method of catching fishes in India have been found in the literature, I wish to narrate the following facts observed at widely separated places in India in the course of the last 32 years.

Punjab. During winter months at Lahore, Western Punjab, when the temperature falls almost to the freezing point, a catfish of the river Ravi, a fish locally known at *Khagga* (*Rita rita* Hamilton), seeks shelter among rocks and crevices at the bottom and goes into a semitorpid state. This fish possesses three very strong

spines, one in the rayed dorsal fin, and one in each pectoral fin. With these spines, the fish can inflict serious injuries and is, therefore, greatly dreaded by local fishermen. During the cold months, fishermen dive to the hiding places of the fish and in a very ingenious way catch them with their hands. When the presence of a benumbed and inactive fish is felt with the hand, the dorsal spine is held between the first and middle fingers while the thumb and the other fingers are pushed behind and below the pectoral spines on the two sides. In this way the fish is held fast without any likelihood of its using the spines for offense or defense. This method of catching *Khagga* fish by hand is commercially employed, as at this season they cannot generally be netted from the river, but are sold in streets by hawkers in considerable quantities. These observations were made as early as 1917-19, when, as a student, I was engaged in the study of the fishes of Lahore.

Manipur Valley, Assam. In the course of my fish and fishery survey in the Manipur Valley, Assam, in 1920, I learned that the hill-stream fishes of the genus *Glyptothorax* Blyth were locally called *Nga-pang*, "innocent fish." As an explanation of the name (*Rec. Ind. Mus.*, 1921, 22, 173) I was informed that the fish does not dart away when touched with the hand in a rapid current but instead remains more firmly fixed to the rock and is thereby easily caught with the hands. The fishes of this genus, as the name implies, are provided with a thoracic adhesive apparatus consisting of longitudinal ridges and grooves which converge anteriorly. In its natural habitat, any kind of disturbance implies a stronger current, so the reaction of the fish must be to stick faster to rocks to prevent itself from being swept away by the current.

Bengal, Bihar and Orissa. Catching fishes with the hands is a common sight all along the roads and railway tracks in Bengal, Bihar, and Orissa, when the shallow borrow pits begin to dry in February and March. Boys and girls move about in the mud feeling for the fishes with their hands and feet, and usually catch some. Those that may be left behind are dug up when the surface becomes firm. The fishes that burrow are those that are capable of using atmospheric air direct for respiration. If these drying-up pools are not combed out with the hands in the way indicated, the birds carry away the fishes that may be left on the beds of dried-up pools, and sometimes deposit them on trees. From such instances have originated the stories of fishes' climbing trees, particularly regarding *Anabas*, the so-called tree-climbing perch of the Orient.

It seems probable that catching fishes with the hands may have started with the drying up of pools in the tropics, where fishes could be seen wriggling about in

the mud and thereby could be readily captured with the hands. Of course, when fishes sometimes come down with rains, then the means employed to catch them are the hands, and this phenomenon is not very rare so far as India is concerned (*vide* Hora, S. L. *J. roy. Asiatic Soc. Bengal*, 1933, 29, 95).

S. L. HORA

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Relation Between Time of Treatment and Sprouting of Poisoned Trees

The burning of woods and past logging practices (harvesting the best trees and leaving the worst) have enabled hardwood species of little or no commercial value to dominate millions of acres of forest, range, and pasture land in the South and elsewhere. One of several successful control measures for such trees has been developed by F. A. Peery and R. S. Campbell, working with blackjack oak, *Quercus marilandica*, in central Louisiana (*J. Forestry*, 1949, 47, 443). Their recommendations are to cut off small trees close to the ground and to apply one tablespoonful of ammonium sulfamate crystals immediately to the freshly cut stump. On trees larger than about 4 in. in diam, notches are cut 6 in. apart around the base of the trunk, and one tablespoonful of chemical is placed in each notch.

In testing these methods on hardwood species in the Ozark Mountains of north Arkansas, a trial was made to see if tree mortality and resprouting were affected by the time of day at which the poison was applied. The test was made on common persimmon, *Diospyros virginiana*, a species hard to kill without resprouting. The poison was applied at 6 a.m., 4 p.m., and 8 p.m.; about 50 saplings 1-4 in. in diam (measuring 4½ ft above ground) were treated each time. A small notch was cut in each stem near the ground and filled immediately with ammonium sulfamate crystals. Treatments were applied in August 1948.

Examination, late in July 1949, showed that the crowns of all the trees had been killed and that only a few trees of the entire lot had developed basal sprouts. The most striking results, however, were the differences in epicormic branching (stem sprouting) between trees treated at different times of day. Stem sprouts were found on only 25% of the saplings treated at 6 a.m., on 55% of those treated at 4 p.m., and on 67% of those treated at 8 p.m. These preliminary tests will be followed by additional experiments on other species and at different seasons.

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Book Reviews

Mathematical Biophysics. Revised edition. N. Rashevsky. Chicago: Univ. Chicago Press, 1948. Pp. 669. \$7.50.

The rarity of investigations and books (rarity in English, and indeed, comparative rarity in other languages) devoted to theoretical aspects of biology is one of the primary factors that make this volume a most valuable contribution in its field, as well as one of interest to students and investigators in many other fields of science. As an attempt to formulate a theoretical biology which can accomplish in this field what theoretical physics and chemistry have in theirs, this work is indeed most welcome. Since, however, the mass of available quantitative biological data is so pitifully small, the author and his colleagues have in many cases been compelled to use more or less crude formulations. In spite of that fact, however, they have been able to complete a surprising number of descriptive studies, as well as many estimates of biological quantities.

Since this is a revision of a former edition, a minutely detailed tabulation of the contents is scarcely necessary. The book is divided into four sections: I. Mathematical biophysics of vegetative cells, II. Mathematical biophysics of excitation and conduction in peripheral nerve, III. Mathematical biophysics of the central nervous system, and IV. The organism as a whole and the organic world as a whole. Twenty-nine of the original 30 chapters of the first edition have been retained, and 24 new chapters added, taken primarily from the author's *Advances and Applications of Mathematical Biology* and other publications by his colleagues and associates. It is of interest that (as can be seen from the sections titles) the work concerns itself in large measure with considerations relative to the nervous system, although certain specific cell problems are discussed as well—for example, diffusion, respiration, and growth. The author, in the prefaces and explanatory remarks, has carefully pointed out the more obvious shortcomings of the volume, so that this reviewer feels that it will be of greater value to discuss the work from a more general point of view.

In considering the book, and the "young and new field" it attempts to present, one wonders immediately what they hope to accomplish. The author states that

... it is very important to emphasize that we do not claim to "explain" away all phenomena of life in terms of physics. Whether such a thing is possible or not is for the future to decide. Perhaps biology will eventually have to develop on the basis of some postulates which are not necessarily reducible to present-day physics. This will still not preclude a "mathematical" biology. Inasmuch, however, as biological phenomena are very closely related to physical phenomena, we shall in this book, whenever possible, look for physical interpretations, in line with the desire to unify all natural sciences.

These statements leave one with feelings of dissatisfaction in several directions. A satisfactory mathematical biology, from the point of view of the biologist, would either help to fill the hole created by lack of quantifica-

tion in this field, or would set itself the task of pointing out paths for the experimentalist to follow in an effort to increase the meager information now available to those who see the importance of being able to analyze biological events in ways similar to those of chemistry and physics. To be sure, to many investigators, and especially to mathematicians, there is great value as well as a certain elegance in the mathematical construction of a given problem. To biologists, however, many of whom are not customarily given to this type of thinking, the power of mathematical analysis lies in its ability to go beyond the experiment and available empirical data, to the formulation of a hypothetical principle, which may or may not then be validated in the laboratory.

It must be remembered, however, that life as a parameter of unknown nature plays a part and is one of the great difficulties in any mathematical treatment of biological problems which attempts to rise above the physical explanation of special detailed phenomena. Living matter is intricate and complex, and an analysis of what in many instances may be oversimplified models thus suffers from severe limitations. This does not mean that the discovery of statistical laws of biological nature and behavior expressible in mathematical terms is impossible, but it is very discouraging to be confronted with the possibility that the great weakness of biological studies over the centuries—namely, their almost purely descriptive nature—will infiltrate the mathematical analyses to the point where mathematics becomes only a technique employed for a new symbolic type of description. It would appear that the important contribution of a "mathematical" biophysics is not to "unify the natural sciences," but first to find or lead to the discovery of purely biological principles, and then to discuss them in a mathematical way in order to elucidate their nature and interpret their consequences. It is not enough to describe specific events, although a certain amount of important information can be, and already has been, gained in this way.

For example, it is of great value, as shown in one of the studies in the present volume, to give us indications as to the order of magnitude of such constants as the permeability of the cell membrane to oxygen, and the diffusion coefficient of oxygen in the protoplasm. It would be remarkably stimulating to the biologist, however, if in addition to such specific problems an attempt were made to consider metabolism as a whole, and to set up general metabolic equations which might be applied to the further analysis of any aspect of the dynamics of the organism.

The section of the book concerned with the nervous system demonstrates, among other things, the need for a further mathematical analysis which would indicate more as to the exact nature of this system, its units, and their role in the general behavior of the living organism. The analysis presented here does, however, point out

where some of the necessary information is lacking, and develops a physicomathematical approach to nervous activity which fits a certain amount of the experimental data and has been extended to include the recent work of McCulloch and Pitts, the implications of which are remarkably intriguing. The method they employ (in terms of Boolean algebra) and certain of Rashevsky's studies appear to go a long way toward providing not only description of neural events in quantitative terms, but also prediction of certain factors. How far these studies will lead toward the formulation of fundamental laws of behavior and activity is still uncertain. The excitation theory, perhaps of necessity, is partially based on certain assumptions which one may or may not accept, and is limited, as the author states, to "a purely phenomenological mathematical descriptive point of view."

The author has also included sections on learning, abstraction, logical thinking, visual perception and esthetics, and other mental phenomena. Any effort to clarify these complex and vague states and functions is to be applauded, and it is undeniably stimulating to see an attempt to put them into mathematical terms. One of the great values of this book is the kind of thinking it represents, and this makes it, despite all the shortcomings and limitations of its subject, a treatise of importance to both the mathematician and the experimental biologist.

ROBERT G. GRENNELL

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Human Helminthology: A Manual for Physicians, Sanitarians, and Medical Zoologists. Third edition. Ernest Carroll Faust. Philadelphia: Lea and Febiger, 1949. Pp. 744. Illustrated. \$10.00.

The third edition of Dr. Faust's popular *Human Helminthology* includes much of the new information in parasitology accumulated during the war. This is reflected particularly in those sections dealing with Bancroft's filariasis and schistosomiasis japonica, two of the helminthic diseases which become important military health problems in the Pacific campaigns.

The basic pattern of presentation follows that used in the earlier editions. Following the first section, which deals with general aspects and modern-day concepts of helminthic infections, each important species is considered in detail as to taxonomy, historical background, geographical distribution, structure, life cycle, epidemiology, pathogenesis, symptomatology, diagnosis, treatment, prognosis, and control. A glossary of over 200 medical and zoological terms has been added. Two new sections deal with the pathogenesis and clinical aspects and with the control of helminthic infections. A chapter on leeches has been incorporated. Supplementary and detailed material has been printed in smaller type, making this edition more adaptable as a classroom text. This, combined with the use of a larger printed page size, has made it possible to include additional material without increasing the thickness of the book.

One of the most useful features of the book from the standpoint of the medical zoologist is the chapter on scientific nomenclature which includes the International Code

of Zoological Nomenclature. Additional explanation of the code has been incorporated in this edition, along with opinions rendered by the International Commission on Zoological Nomenclature and the Committee on Terminology of the American Society of Parasitologists.

The section dealing with anthelmintics has been completely revised and brought up to date. New illustrations have been added and certain older ones improved. Some of the newer, more effective technical procedures have been included in the revised large section on diagnostic methods. The extensive classified bibliography affords an excellent source of references on all of the various aspects of medical helminthology.

Revised editions of accepted and well-known textbooks should offer more than a mere rearrangement or rewording of the subject matter. Dr. Faust has accomplished this to the extent of preparing an edition which will be useful to workers in the field who already own copies of the earlier editions.

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Scientific Book Register

This Is Race: An Anthology Selected from the International Literature on the Races of Man. Earl W. Count, Ed. New York 21: Henry Schuman, 1950. 747 pp. \$7.50.

The Alkaloids: Chemistry and Physiology, Vol. 1. R. H. F. Manske and H. L. Holmes, Eds. New York: Academic Press, 1950. 525 pp.; illustrated. \$10.00.

L'Organisation des Os. Pierre Lacroix. Paris VI^e: Masson et Cie, 1949. 230 pp.; illustrated. 900 fr.

Brazilian Culture: An Introduction to the Study of Culture in Brazil. Fernando de Azevedo. Trans. by William Rex Crawford. New York: Macmillan, 1950. 562 pp.; illustrated. \$12.50.

Thermodynamics: Principles and Applications to Engineering. Ernst Schmidt. Trans. from 3rd German ed. by J. Kestin. New York 11: Oxford Univ. Press, 1949. 532 pp.; illustrated. \$7.00.

Metals Reference Book. Colin J. Smithells, Ed. London: Butterworths Scientific Publs.; New York: Interscience, 1949. 735 pp.; illustrated. \$13.50.

Selenium: Its Geological Occurrence and Its Biological Effects in Relation to Botany, Chemistry, Agriculture, Nutrition, and Medicine. Sam F. Trelease and Orville A. Beath. New York: The authors, 1949. 292 pp., illustrated. Order from S. F. Trelease, Box 42, Schermerhorn Hall, Columbia University, New York 27, N. Y. \$5.50.

Design This Day: The Technique of Order in the Machine Age. Rev. ed. Walter Dorwin Teague. New York: Harcourt, Brace, 1949. 285 pp.; illustrated. \$6.00.

Archeology of the Florida Gulf Coast. Gordon R. Willey. Washington, D. C.: Smithsonian Institution, 1949. 599 pp., 60 plates; illustrated. \$4.00.

NEWS and Notes

The National Science Foundation Act (H. R. 4846) was passed by the House of Representatives on March 1 by a vote of 247 to 125. A Senate-House conference will now be necessary to resolve the differences between the House bill and the one passed last March by the Senate. Members of the conference committee have not yet been named. The most serious difference between the two bills is a last-minute amendment to the House bill requiring the FBI to investigate and to approve every Foundation employee and scholarship holder. Since in the judgment of a large number of scientists such a requirement will seriously damage the effectiveness of the Foundation, strong efforts will be made to have this provision removed by the conference before the bill is reported back to the two houses for final action.

About People

C. O'D. Iselin, director of the Woods Hole Oceanographic Institution since 1940, will resign from administrative duties on July 1 in order to devote full time to scientific studies. He will divide his time between the institution, as senior oceanographer, and the Museum of Comparative Zoology at Harvard University, where he is associate professor of physical oceanography. Dr. Iselin hopes to give considerable time to possibilities of tapping new resources in the sea for world food requirements.

Marshall Clagett, associate professor of the history of science at the University of Wisconsin, is planning his third trip to the libraries of England, France, and Italy, to record on microfilm the parchment manuscripts of such 13th and 14th century scientists as Jordanus, Ockham, Buri-

dan, Heytesbury, and Oresme. He is collecting the work of these men, which foreshadowed that of Galileo, as an example of the evolution of knowledge.

John T. Buchholz, University of Illinois botanist, has been appointed correspondent of the National Museum of Natural History of Paris, in recognition of his outstanding research on the flora of New Caledonia. Dr. Buchholz plans to continue this work, using the museum's collection, during the summer.

Ralph B. Hogan, veteran research worker in venereal disease, has been named chief of laboratory services for the Communicable Disease Center of the U. S. Public Health Service in Atlanta. Dr. Hogan, who has been chief of clinical and laboratory research for the Venereal Disease Division in Washington for the past two years, succeeds **Seward E. Miller**, now regional director for the Federal Security Agency in Chicago.

Stafford L. Osborne, professor of physical medicine, Northwestern University Medical School, Chicago, has been appointed chairman of the department to succeed the late John Stanley Coulter. The appointment was effective January 1.

Frederick G. Sawyer, editorial representative of the western states for the American Chemical Society, has joined the Stanford Research Institute to administer its air and water pollution research programs.

Lester W. Burket, professor of oral medicine at the University of Pennsylvania School of Dentistry, has been named visiting professor to the dental schools of the National University at Bogota, and the University of Antioquia at Medellin, Colombia.

Martin W. Goldner, director of medical research and chief of the gastrointestinal and metabolism section of the Veterans Administration Hospital, Fort Logan, Colorado, has been appointed chief of medicine at the Fort Hamilton Veterans Administration Hospital, Brooklyn, New York.

Visitors to U. S.

Ezidio Bertorello, of the Research Department, Instituto Ricostituzione Industriale, Rome, is studying metallurgical engineering at the University of Pittsburgh under the Fulbright program.

B. Mygaard-Ostby, professor of dentistry, Norwegian College of Dentistry, Oslo, and **G. H. Guest**, senior scientific officer with the Health Radiation Section, National Research Council, Ottawa, Canada, recently visited the National Bureau of Standards.

Grants and Awards

The 1950 Medal of Honor of the Institute of Radio Engineers was presented to **Frederick E. Terman**, dean of the Stanford University School of Engineering, at the annual IRE convention in New York City on March 8. Dean Terman was honored for his many contributions to the radio and electronics industry as teacher, author, scientist, and administrator.

The Chancellor's Medal of the University of Buffalo, New York, was awarded for 1950 to **Ernest Witebsky** on February 22. Dr. Witebsky, professor of bacteriology and immunology and head of the department at the university's Medical School, is the fifth recipient of the award in the field of medical science. He was honored for his research on human blood.

The Swedish Royal Order of the North Star, degree of Commander, has been conferred on **Robert Gordon Sproul**, president of the University of California, in recognition of his accomplishments in cementing friendly relations between the University of California and Swedish universities and scientific institutions.

The Willard Gibbs Medal, conferred annually by the Chicago Section of the American Chemical Society, will be awarded May 19 to **Carl Shipp Marvel**, head of the Department of Organic Chemistry at the University of Illinois. Dr. Marvel is known for his work on synthetic rubber and antimalarial drugs.

Fellowships and Grants-in-aid

Applications for grants in aid of chemical research from the **Cyrus M. Warren Fund of the American Academy of Arts and Sciences** should be received by the chairman of the committee, Frederick G. Keyes, Massachusetts Institute of Technology, Cambridge 39, not later than May 1. Grants are seldom in excess of \$300 and are made generally for apparatus and supplies needed for research. No funds are awarded for salaries. Application blanks will be sent upon request.

A graduate fellowship leading to a Ph.D. degree in chemical engineering has been established at the Illinois Institute of Technology by the **Federation of Paint and Varnish Production Clubs**. It includes a grant of \$1,350 and \$660 tuition for two semesters and a summer session. The fellow selected will engage in research on fume recovery in varnish plants. Applications should be sent to the dean of the graduate school, Illinois Institute of Technology, Chicago 16, before July 1.

Summer Programs

The **1950 Institute for Annual Review of United Nations Affairs** will be held June 26-30, under the joint auspices of the Program of Studies in United Nations and World Affairs of New York University and the Department of Public Information of the UN. Day sessions will be held at Lake Success, evening sessions at New York University. The activities of the United Nations during the past year will be reviewed by UN officials, and panel discussions will follow. Inquiries should be addressed to Clyde Eagleton, Director of the Program in United Nations and World Affairs, New York University, New York City.

The **Roscoe B. Jackson Memorial Laboratory** is offering cooperative research facilities for the summer to a limited number of young workers with interests related particularly to the laboratory's programs in growth and social behavior of animals. Investigators are selected on

the basis of capability for independent research and suitability of the research plan submitted. Each visiting investigator is sponsored by a resident staff member who assists in cooperative planning. Application blanks may be obtained from the Summer Investigators Committee, Box 847, Bar Harbor, Maine. The period of residence will be from June 12 to September 3.

The regular summer programs of the laboratory begin June 21 for guided research studies in problems of growth and problems of social behavior of mammals. Applications may be obtained from the Summer Studies Committee, Jackson Laboratory, and must be returned before April 15. A fee of \$140 is required to defray costs of board and room and operation of the laboratory, but no tuition is charged for the course.

Meetings and Elections

A **symposium on conservation** will be sponsored by the Springfield chapter of the AAAS, March 21, in the auditorium of the Museum of Fine Arts, Springfield, Massachusetts, under the chairmanship of **Arthur T. Lyman**, commissioner of conservation, Commonwealth of Massachusetts. Speakers will be **Hugh H. Bennett**, chief, Soil Conservation Service, U. S. Department of Agriculture; **H. B. Kinnison**, U. S. Geological Survey engineer; **Raymond Kienholz**, University of Connecticut; and **Reuben F. Trippensee**, University of Massachusetts. There will be special exhibits at the Natural History Museum, through the courtesy of Leo Otis, director. Further information may be obtained from P. H. Clinis, 633 Chestnut Street, Springfield 7, Massachusetts.

The **third annual meeting of the American Association of Blood Banks** will be held October 12-14 at the Stevens Hotel in Chicago. The program is being planned to attract blood bank workers, hospital administrators, pathologists, clinicians, surgeons, and others interested in procuring and preserving blood and blood derivatives. For further information write the Office of the Secretary, 3301 Junius Street, Dallas 1, Texas.

The **Midwest Power Conference**, sponsored by the Illinois Institute of Technology with the cooperation of 18 other midwestern organizations, will hold its 12th annual meeting at the Sherman Hotel in Chicago, April 5-7. Participation is open to anyone interested in problems of power production, transmission, or consumption. Preregistration may be made through Edwin R. Whitehead, Conference Secretary, Illinois Institute of Technology, 3300 Federal Street, Chicago 16.

The **Sixth National Chemical Exposition**, sponsored by the Chicago Section of the American Chemical Society, will be held in the Chicago Coliseum, September 5-9, concurrently with the 118th national meeting of the ACS. "A Half Century of Chemical Progress" will be the theme of the exposition, in which contributions of chemical science and industry will be emphasized and the history of the development of many phases of chemistry and new industries will be presented. As in previous expositions, "Chemical Trail Blazer" displays will be featured, showing the latest developments in the chemical field. Space for these exhibits will be available free to individual scientists for noncommercial displays of their outstanding work. Inquiries may be addressed to James J. Doheny, Exposition Manager, 86 East Randolph Street, Chicago.

A conference cosponsored by the **Foundation for Integrated Education and Oklahoma Agricultural and Mechanical College** will be held June 6-9 at Stillwater, Oklahoma. The chief function of the foundation, whose president is Kirtley F. Ma-ther, president elect of the AAAS, is to give assistance to college and university faculties in developing integrated programs. The aim of the conference is "to explore the possibilities of a unified conceptual structure as the basis for unifying group attitude and action. . . . The view of knowledge as dynamic as well as cognitive will be made explicit." Formal papers will be presented by **F. S. C. Northop**, of Yale University, general chairman of the conference; **Henry Margenau**, also of

Yale, chairman of the foundation's board; *Clyde Kluckhohn*, Harvard University; and *Muzafer Sherif*, University of Oklahoma. These papers will be followed by small group discussions by conference participants. Inquiries should be sent to the Foundation for Integrated Education, 60 East 42nd Street, New York City 17.

During the fourth annual meeting of the **Society for the Study of Evolution** held December 27-30, the following officers were elected: president, Ernst Mayr, American Museum of Natural History; vice presidents, Alfred S. Romer, Museum of Comparative Zoology, Harvard University; Stanley A. Cain, Cranbrook Institute of Science; David Lack, Edward Grey Institute of Field Ornithology, Oxford, England; secretary, Theodor Just, Department of Botany, Chicago Natural History Museum; treasurer, Karl P. Schmidt, Department of Zoology, Chicago Natural History Museum; and editor, Edwin H. Colbert, American Museum of Natural History.

The American Venereal Disease Association and the Experimental Therapeutics Study Section of the National Institutes of Health will jointly sponsor a **symposium on advances in clinical and laboratory research in venereal disease**, to be held in the Department of Agriculture Auditorium, Washington, D. C. on April 27 and 28. Requests for information should be sent to Francis L. Schmehl, National Institutes of Health, Bethesda 14, Maryland, or to William L. Fleming, Secretary, American Venereal Disease Association, 750 Harrison Avenue, Boston, Massachusetts.

NRC News

A Handbook of Clinical Nutrition, prepared by the NRC Food and Nutrition Board's Committee on Diagnosis and Pathology of Nutritional Deficiencies, will be published this month. This handbook, designed to complement the material in the American Medical Association's *Handbook on Nutrition*, discusses nutrition and health and the patho-

genesis of deficiency disease, and considers in detail the clinical signs and methods of diagnosis. It also includes chapters on diet therapy, and nutrition in public health and in industrial medicine.

The NRC Division of Geology and Geography announces that the 1948-49 *Report of the Committee on the Measurement of Geologic Time* is now available. The report reviews research bearing on the problem of the age of the earth and the dating of minerals and geologic features, and also discusses work in progress on measurement of radioactivity, chemical composition, and isotopic composition of minerals. It includes an annotated bibliography of articles relating to measurement of geologic time.

Deaths

George R. Minot, 1934 Nobel prize winner (with William P. Murphy and George Whipple) for his discovery of the liver treatment as a cure for pernicious anemia, died February 25 at his home in Brookline, Massachusetts. He was 64 years old. Dr. Minot retired as professor of medicine at the Harvard Medical School in July 1948.

John H. Reedy, professor emeritus of chemistry at the University of Illinois, died February 21 at the age of 71, following a long illness. Dr. Reedy was a member of the university's Chemistry Department for 28 years and was well known for his books on quantitative analysis.

Carlos de la Torre, professor emeritus of zoology, University of Havana, died February 19 at his home in Havana at the age of 91. Dr. de la Torre was an expert on shellfish of Cuba and the Caribbean area and had collaborated with Paul Bartsch of the Smithsonian Institution on a book on shellfish.

Samuel Newton Taylor, 91, professor emeritus of physics, Goucher College, died January 8. He had taught at Purdue, Syracuse, Pittsburgh, and Cincinnati Universities, and at Goucher College from 1911 until his retirement in 1933.

Miscellaneous

Heinz Specht, of the National Institutes of Health, Bethesda 14, Maryland, requests that students and friends of **E. A. Andrews**, professor emeritus of zoology, Johns Hopkins University, who passed his ninetieth birthday September 10, 1949, contribute letters for a commemorative volume. It is suggested that a snapshot be included, space for it being provided in the letter. Letters should be addressed to Dr. Andrews but sent to Dr. Specht.

Complete English translation of the *Journal of Applied Chemistry of the USSR* will be available to American research laboratories and libraries, beginning with the January 1950 issue, from the Consultants Bureau, 153 West 33rd Street, New York City. Subscribers will receive complete translation of each 1950 issue within seven weeks after its arrival in this country, and several months in advance of the abstract literature. Subscription to the entire Vol. 23 (1950) is \$80.

Consultants Bureau is also publishing in English translation the *Journal of General Chemistry of the USSR*. The January, February, March, April, and September (1949) issues are already available. Subscribers will receive all 1949 issues by June 30 and all 1950 and subsequent issues within eight weeks after receipt of each issue in the U. S. Annual subscription is \$95.

At a recent meeting of the Board of Directors of the Academy of World Economics the name of that organization was changed to **The National Academy of Economics and Political Science**. The academy was founded in 1922 and has held 27 annual sessions. Its objectives are to promote a wider understanding of national and international economic and political problems. Proceedings of all sessions are published in the quarterly journal, *Social Science*. Benjamin H. Williams is the chairman of the board and Donald P. Ray is the executive secretary. Administrative offices are in the Hall of Government, George Washington University, Washington, D. C.



Saul H. Sternberg, 16, of The Bronx, N. Y., senior at High School of Music and Art, winner of the \$2,800 Westinghouse Grand Science Scholarship.



Donald B. McCormick, 17, of Oak Ridge, Tennessee, senior at Oak Ridge High School, winner of second place \$2,000 Westinghouse science scholarship.

Winners of the **ninth annual Westinghouse Science Talent Search**, conducted by Science Service, were announced March 6 at the closing banquet of the five-day Science Talent Institute at the Hotel Statler in Washington, D. C. Harlow Shapley, director of the Harvard College Observatory and chairman of the board of judges of the Science Talent Search, presented the scholarship awards.

Saul Sternberg, winner of the Westinghouse grand science scholarship, is an inventor and student of biology in addition to his major interest in nuclear physics. In preparation for the Talent Search, Saul undertook the measurement of the tracks made by helium atoms across a photographic plate and calculated the energy released by cyclotron bombardment. The helium was produced by bombarding boron with neutrons. Saul used photographic plates impregnated with boron and persuaded Washington University at St. Louis to bombard them with neutrons in their cyclotron.

Donald Bruce McCormick, who won second place in the nationwide competition, plans to be a biochemist after graduation from the University of Tennessee. He has been studying the abnormal outgrowths, or galls, often found on goldenrod plants. Because certain galls have been shown to be a definite type of plant

cancer, Donald thinks that their study may lead to helpful knowledge about cancer.

Eight other teen-age scientists were awarded \$400 scholarships. They are: *Malcolm S. Gordon*, 16, of Brooklyn, New York; *Robert W. Detenbeck*, 17, of Kenmore, New York; *William D. Gunter, Jr.*, 18, of Bellingham, Washington; *Dennis P. Malone*, 17, of Kenmore, New York; *William J. Reeves, Jr.*, 17, of Springfield, Oregon; *Lenore Y. Taylor*, 17, of Utica, New York; *William G. Tift*, 17, of Seymour, Connecticut; *Cynthia W. Wyeth*, 16, of North Hills, Philadelphia, Pennsylvania. Thirty other finalists were awarded scholarships of \$100 each.

The judges of the Search, in addition to Dr. Shapley, are Harold A. Edgerton and Stuart H. Britt, New York psychologists, and Rex E. Buxton, Washington psychiatrist.

The awards banquet was presided over by Watson Davis, director of Science Service. A. C. Monteith, chairman of the Westinghouse Educational Foundation and vice president of the Westinghouse Electric Corporation, welcomed the winners and outlined the role of his company in the conduct of the Search. J. Robert Oppenheimer, director of the Institute for Advanced Study at Princeton, New Jersey, delivered the principal address.

The 40 trip winners were chosen

after a competition of top-ranking seniors in public, parochial, and private schools throughout the U. S. Entrants, representing all 48 states and the District of Columbia, totaled 13,500, of whom 2,245 completed the stiff science aptitude examination, submitted recommendations and scholarship records, and wrote an essay on "My Scientific Project."

The scholarships may be used at any college, university, or technical school of the winners' choice so that they may continue their training in science or engineering. Chosen on the basis of ability and aptitude alone, without regard to geographic distribution, the 40 scholarship winners come from 15 states.

Recently Received—

The Natural Resources Building on the University of Illinois campus, shared by the **Illinois State Geological Survey and the State Natural History Survey**, is being enlarged at a cost of \$1,765,000 by the addition of an east and west wing, which will double the space for both organizations. The Geological Survey has a separate Applied Research Laboratory for large scale work, built in 1940, at a cost of approximately \$150,000.

M. M. Leighton, chief of the Illinois Geological Survey, reports that the last General Assembly of the State of Illinois made appropriations for the current work of the survey in the amount of \$1,438,530 for 1949-1951—an increase of \$331,940 over the preceding biennium—and also authorized higher salaries for the scientific and technical staff.

In 1931 the survey was reorganized to comprise sections on geological resources, geochemistry, mineral economics, and an education extension division. Its work includes fundamental research as well as applied studies. Topographic maps have been prepared for ninety percent of the state. There are 125 full-time employees on the present staff, including 37 geologists, 12 chemists, 2 physicists, 3 engineers, 2 mineral economists, 9 supervisory assistants, and 33 research and technical assistants. Many students also work part time for the survey.

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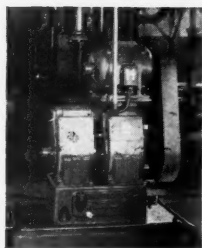
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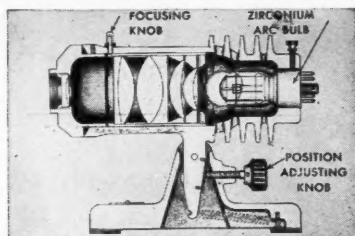
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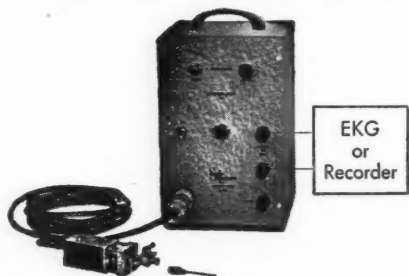
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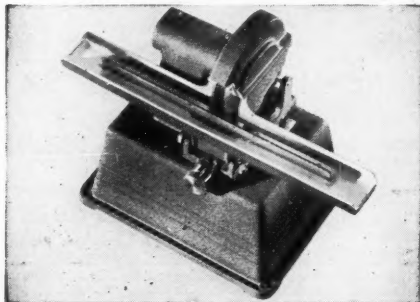


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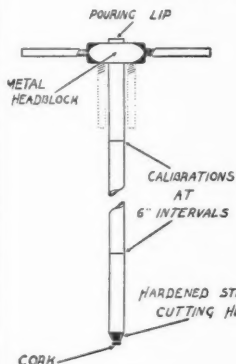
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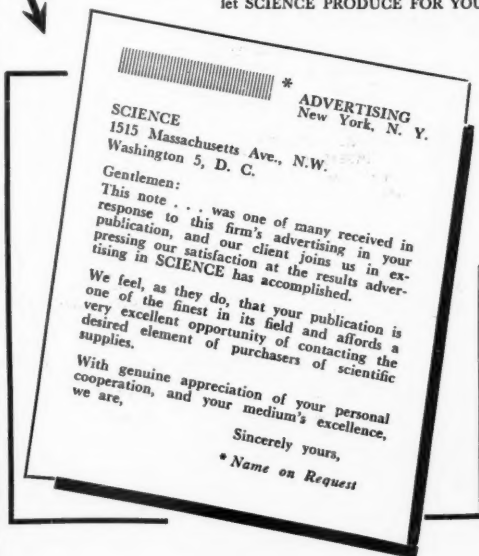
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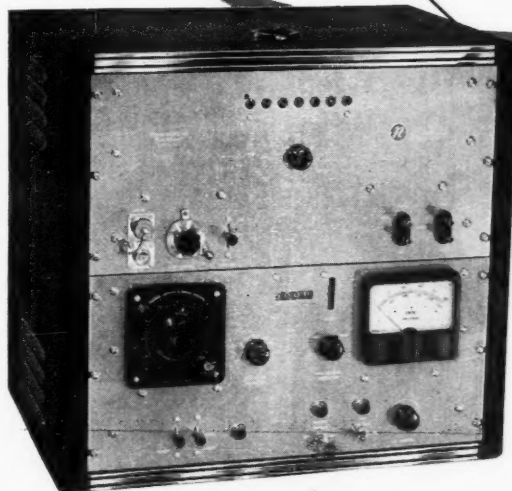
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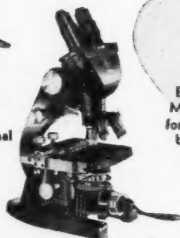
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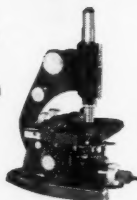


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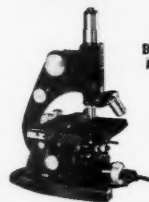
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